FINAL REPORT

Low Temperature Cure Powder Coatings

ESTCP Project WP-200614

October 2010

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ESTCP

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*: 10-01-2010

2. REPORT TYPE: Final Report

3. DATES COVERED *(From - To)*: 06/2006 - 12/2009

4. TITLE AND SUBTITLE
Low Temperature Cure Powder Coatings (LTCPC)

5a. CONTRACT NUMBER: FA8903-08-D-8779

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

5d. PROJECT NUMBER: ESTCP WP-0614

5e. TASK NUMBER

5f. WORK UNIT NUMBER

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Wright-Patterson AFB, OH 45433

10. SPONSOR/MONITOR'S ACRONYM(S): HQ AFMC/A4BE

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Distribution Statement "A" applies. Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This Environmental Security Technology Certification Program (ESTCP) project focused on demonstrating and validating the use of LTCPC on Air Force and Navy components that currently undergo solvent based coating applications. Locations for Air Force and Navy demonstration and initial implementation of this powder coat technology are the service-level logistics centers, such as the U.S. Air Force's Ogden Air Logistics Center (OO-ALC), Hill Air Force Base, UT and the U.S. Navy's Aircraft Intermediate Maintenance Detachment, Naval Air Station Whidbey Island, WA. Concurrent Technologies Corporation, Johnstown, PA and Naval Air Systems Command, Patuxent River, MD supplemented OO-ALC's existing onsite testing capabilities during the Joint Test Protocol phase of this effort.

15. SUBJECT TERMS
Aerospace Coatings, Powder Coatings, Low Temperature Cure

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
U	U	U	UU	40	Warren Assink
					19b. TELEPHONE NUMBER *(Include area code)*: 937-904-0151

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ACRONYMS AND SYMBOLS

AC	Aircraft
ADG	Accessory Drive Gearbox
AFB	Air Force Base
AFCEE	Air Force Center for Engineering and the Environment
AFMC	Air Force Materiel Command
AFRL	Air Force Research Laboratory
ALC	Air Logistics Center
AMAD	Aircraft Mounted Accessory Drive
AMS	Aerospace Material Specification
ANA	Area Not Accessible
ASTM	American Society for Testing Materials
CAA	Clean Air Act
CBA	Cost Benefit Analysis
CCC	Chromate Conversion Coating
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CIELAB	Commission Internationale d'Eclairage (International Commission on Illumination) L*a*b*
COTS	Commercial-Off-The-Shelf
CTC	Concurrent Technologies Corporation
CTIO	Coatings Technology Integration Office
CVCM	Collected Volatile Condensable Material
DoD	Department of Defense
DOI	Distinctness of Image
ECAM	Environmental Cost Analysis Methodology
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-know Act
EQP	Engineering Qualification Plan
ESTCP	Environmental Security Technology Certification Program
FED-STD	Federal Standard
FRC	Fleet Readiness Center
FRCE	Fleet Readiness Center East
FRCNW	Fleet Readiness Center Northwest
FRCSE	Fleet Readiness Center Southeast
FRCSW	Fleet Readiness Center Southwest
FSE	Field Service Evaluation
FY	Fiscal Year

GE	General Electric Corporation
GM	General Motors
GSE	Ground Support Equipment
HAP	Hazardous Air Pollutant
HVLP	High Volume, Low Pressure
IR	Infrared
IRR	Internal Rate of Return
JTP	Joint Test Protocol
JTR	Joint Test Report
KSC	Kennedy Space Center
LCC	Life Cycle Costs
LTCPC	Low Temperature Cure Powder Coating
MEK	Methyl Ethyl Ketone
MIBK	Methyl IsoButyl Ketone
MIL-PRF	Military Performance Specification
MSDS	Material Safety Data Sheet
N/A	Not Applicable
NAS	Naval Air Station
NASNI	Naval Air Station North Island
NASWI	Naval Air Station Whidbey Island
NASA	National Aeronautics and Space Administration
NAVAIR	Naval Air Systems Command
NDCEE	National Defense Center for Energy and the Environment
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NIOSH	National Institute for Occupational Safety and Health
NPV	Net Present Value
N/R	Not Reported
NT	Not Taken
OC-ALC	Oklahoma City Air Logistics Center
O&M	Operations and Maintenance
OMB	Office of Management and Budget
OO-ALC	Ogden Air Logistics Center
OSHA	Occupational Safety & Health Administration
PC	Powder Coating
PEL	Permissible Exposure Limit
PMB	Plastic Media Blasting
PPE	Personal Protective Equipment
QPD	Qualified Products Database

RCRA	Resource Conservation and Recovery Act
RED	Reregistration Eligibility Decision
SAE	Society of Automotive Engineers
SAIC	Science Applications International Corporation
SERDP	Strategic Environmental Research and Development Program
SN	Serial Number
SOP	Standard Operating Procedures
ST	Steel
TCLP	Toxicity Characteristic Leaching Procedure
TGIC	Triglycidyl Isocyanurate
TO	Technical Order
TM	Technical Manual
TML	Total Mass Loss
TRI	Toxics Release Inventory
USAF	United States Air Force
USN	United States Navy
UV	Ultraviolet
VOC	Volatile Organic Compound
WR-ALC	Warner Robins Air Logistics Center
WVR	Water Vapor Regained

PREFACE

This Final Report was prepared by Science Applications International Corporation (SAIC) under Air Force Center for Engineering and the Environment (AFCEE) Contract Number FA8903-08-D-8779, Task Order 0015 in support of the Environmental Security Technology Certification Program (ESTCP) Project WP-0614.

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

- Air Force Materiel Command, Wright-Patterson AFB, OH
- Boeing, Huntington Beach, CA
- Coatings Technology Integration Office, Wright-Patterson AFB, OH
- Concurrent Technologies Corporation, Johnstown, PA
- Crosslink Powder Coatings, Inc
- Fleet Readiness Center Northwest, NAS Whidbey Island, WA
- Fleet Readiness Center Southeast, NAS Jacksonville, FL
- Fleet Readiness Center Southwest, NAS North Island, CA
- National Aeronautics and Space Agency, Kennedy Space Center, FL
- Naval Air Systems Command, Lakehurst, NJ
- Naval Air Systems Command, Patuxent River, MD
- Ogden Air Logistics Center, Hill AFB, UT
- Oklahoma City Air Logistics Center, Tinker AFB, OK
- Warner Robins Air Logistics Center, Robins AFB, GA

EXECUTIVE SUMMARY

BACKGROUND

ESTCP project WP-0614, completed the work associated with transitioning the Low Temperature Cure Powder Coating (LTCPC) into use at DoD maintenance facilities. This project targeted the following major milestones: (1) Conduct additional testing and evaluation of the candidate material to more thoroughly characterize performance (beyond the testing and substrates used in the related SERDP project) utilizing a Joint Test Protocol (JTP), (2) Demonstrate the improvements in the coating process and the superior operational performance of the powder coating on aircraft components and ground support equipment, (3) Validate the environmental benefits associated with the LTCPC on aircraft components and ground support equipment, (4) Quantify the cost, logistics, and performance parameters of baseline coating methods for Air Force and Navy logistics centers and demonstrate the cost-savings potential for transitioning to LTCPC, and (5) Coordinate and facilitate technology transition of the low temperature process into governing documents (e.g., MIL-PRF-24712 and coatings related Technical Orders) and actual depot operations.

OBJECTIVES OF THE DEMONSTRATION

The performance objectives for the LTCPC program were:

Table 1. Summary of LTCPC Performance Objectives

Performance Objective	Demonstration Results
Quantitative Performance Objectives	
Product Testing (JTP):	
• Color	• Not Reported (N/R)
• Gloss	• N/R
• Neutral Salt Fog Corrosion Resistance	
o 2024-T3 Aluminum	• Inconclusive
o 6061-T6 Aluminum	• Passed criteria
o AZ31B Magnesium	• Passed criteria
o 4130 Steel	• Passed criteria
• SO_2 Corrosion Resistance	
o 2024-T3 Aluminum	• Failed criteria
o 6061-T6 Aluminum	• Inconclusive
o 4130 Steel	• Passed criteria
• Cyclic Corrosion Resistance	• Passed criteria
• Filiform Corrosion Resistance	• Passed criteria
• Cross-Cut Adhesion by Tape	• Passed criteria
• Impact Flexibility	• Passed criteria
• Fluids Resistance	• Passed criteria
• Low Temperature Flexibility	• Passed criteria

Performance Objective	Demonstration Results
Field Service Evaluation: • Color • Gloss • Film Thickness • Corrosion	 • Inconclusive • Inconclusive • Not Applicable (N/A) • Passed criteria
Reduction of Hexavalent Chromium Use	• Passed objective
Reduction of Hazardous Waste Generated	• Passed objective
Reduction of Processing Time Requirements	• Passed objective
Qualitative Performance Objectives	
Product Testing (JTP): • Coating Appearance • Strippability	 • Passed criteria • N/A
Field Service Evaluation: • Coating Appearance • Adhesion • Fluids Resistance • Humidity Resistance • Abrasion Resistance • Low Temperature Flexibility	 • Passed criteria • Passed criteria • Passed visual inspections • Passed visual inspections • Passed visual inspections • Passed criteria
Reduction of VOC/HAP Emissions	• Passed objective
Reduction of Rework Activities	• Inconclusive
Reduction of Worker Exposures	• Passed objective

DEMONSTRATION RESULTS

A combination of laboratory test results and actual field evaluations confirmed the suitability of LTCPC as a direct replacement for several wet coating systems that are currently in use on Department of Defense (DoD) aircraft and ground support equipment components. LTCPC demonstration results support the current stakeholder efforts directed at implementing this technology at DoD maintenance facilities.

PERFORMANCE ASSESSMENT

Several performance measurements were reported by field service evaluation (FSE) participants over the course of each item's 12-month FSE. The recorded changes in ΔE color values varied for each FSE component but generally proved to be inconclusive in nature. Gloss measurements were also taken for each FSE component over the course of each item's service evaluation. Recorded specular gloss values varied for each FSE component but generally proved to be inconclusive in nature. Additionally, dry film thickness measurements were documented during the course of each component's FSE and proved acceptable as determined by project stakeholders and field users. Lastly, stakeholders evaluated the surface appearance of the

LTCPC with unaided eyes for visible coating or surface defects. There were no noteworthy surface appearance deficiencies reported during the course of each component's FSE period, outside of the normal level of wear and tear. Overall, the performance parameters were found to be acceptable to all LTCPC stakeholders and operational field personnel involved with the demonstration of this technology.

1.0 INTRODUCTION

1.1 BACKGROUND

The use of traditional coating systems formulated with Volatile Organic Compounds (VOC) and Hazardous Air Pollutants (HAP) presents the Department of Defense (DoD) with a significant burden for environmental compliance, permitting, tracking, storage, operations, disposal, and reporting requirements. Handling and disposal of toxic hazardous waste associated with these coatings is extremely costly, time consuming, and presents risk to human health and the environment. Use of these materials poses risks in the form of fines for non-compliance to federal, state, and local regulations from the EPA and OSHA; fines may be imposed for violations to the Clean Air and Water Acts, National Emissions Standards for Hazardous Air Pollutants (NESHAP), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and Resource Conservation and Recovery Act (RCRA). Senior officials have recognized the increasing environmental demands placed on DoD facilities and have shown continued interest and support of demonstration/validation efforts which reduce dependence on traditional coating systems.

Powder coating is a technology that virtually eliminates the hazardous waste streams associated with conventional painting techniques. These waste streams include air emissions, contaminated booth filters, unused admixed paints and cleaning solvents. Powder coating also greatly reduces employee exposure and liabilities associated with liquid coating (wet solvent) use. The powder coating process distributes a small-particulate mixture of resin and pigment onto a substrate, which is then hardened at high temperature inside a curing oven. Advantages over conventional spray painting include greater durability; improved corrosion resistance; and elimination of drips, runs, and bubbles.

Powder coatings currently in use have a range of applications within the automotive, aerospace, construction, and consumer products industries; however, certain applications are limited due to the process requirements of powder coating. Some components cannot withstand the high temperatures required for curing of the powder coating without degradation. Within the DoD, temperature-sensitive components made of aluminum and magnesium are used extensively on weapons systems due to their durability and low weight. These substrates cannot withstand the high temperature cure (up to 400^{o}F) necessary for powder coatings.

A low temperature cure technology would offer the DoD a VOC and HAP-free material coating system which does not compromise substrate material properties. A candidate material was identified under SERDP project PP-1268 “120°C (250°F) Cure, Durable, Corrosion Protection Powder Coatings for Temperature Sensitive Substrates.” This low temperature cure powder coating (LTCPC) material was produced by Crosslink Powder Coatings, Inc. and designated White 595B-17925, with product number 6191-61003. The LTCPC has the potential to eliminate a significant amount of the toxic and hazardous materials currently being used on the targeted components and equipment without compromising structural integrity.

1.2 OBJECTIVES OF THE DEMONSTRATION

The objectives of the LTCPC program were to:

1. Conduct additional testing and evaluation of the candidate material to more thoroughly characterize performance (beyond the testing and substrates used in the related SERDP project) utilizing a Joint Test Protocol (JTP).
2. Demonstrate the improvements in the coating process and the superior operational performance of the powder coating on aircraft components and ground support equipment.
3. Validate the environmental benefits associated with the use of LTCPC on aircraft components and ground support equipment.
4. Quantify the cost, logistics, and performance parameters of baseline coating methods for Air Force and Navy logistics centers and demonstrate the cost-savings potential for transitioning to LTCPC.
5. Coordinate and facilitate technology transition of the low temperature process into governing documents (e.g., MIL-PRF-24712 and coatings related Technical Orders) and actual depot operations.

The technology was demonstrated on Air Force and Navy components that currently undergo solvent based coating applications. For the Air Force, complex shape application of LTCPC was demonstrated on the interior of C-130 wheel well doors. The remaining USAF components originally identified as part of the project's demonstration plan were removed by stakeholders due to unforeseen process changes unrelated to LTCPC performance. These targeted aircraft components currently use conventional solvent-based coating systems to combat exposure to a wide assortment of aggressive service environments. For the Navy, the LTCPC was applied to J52 aft engine yokes and NAN-4 nitrogen servicing carts. These components were subjected to a minimum 12 month FSE to demonstrate the coatings ability withstand the demanding and corrosive environment of US Navy aircraft carriers. The remaining USN components originally identified as part of the project's demonstration plan had the LTCPC stripped before 12 months of exposure.

The locations for Air Force and Navy demonstration and initial implementation of this powder coat technology are the service-level logistics centers such as the U.S. Air Force's Ogden Air Logistics Center (OO-ALC), Hill Air Force Base (AFB), UT; as well as the U.S. Navy's Fleet Readiness Center Northwest (FRCNW), Naval Air Station Whidbey Island (NASWI), WA, and Fleet Readiness Center Southwest (FRCSW), Naval Air Station North Island (NASNI), CA. Concurrent Technologies Corporation (CTC), Johnstown, PA; Naval Air Systems Command, Patuxent River, MD; and the Coatings Technology Integration Office (CTIO), Wright-Patterson AFB, OH, supplemented OO-ALC's existing onsite testing capabilities for the JTP portion of this effort.

Table 2. Target Hazardous Material (HazMat) Summary

Target HazMat	Current Process	Applications	Current Specifications	Affected Programs	Candidate Parts and Substrates
Chrome (VI)	Aerospace coatings application	Solvent-borne primer application	USAF: • TO 1-1-8 • TO 35-1-3 USN: • NAVAIR 17-1-125	Air Force Navy	USAF: • F-15 AMAD • F-16 ADG • TF33 engine 2nd stage stators • C-130 main landing gear doors USN: • Aero 12C bomb cart • NAN-4 cart • Adjustable length tow bar • J52 aft engine yoke • J52 forward engine yoke • Engine support adapter • HLU-288 bomb hoist
Isocyanates	Aerospace coatings application	Solvent-borne topcoat application		Air Force Navy	
Epoxides	Aerospace coatings application	Solvent-borne primer application		Air Force Navy	
Used booth filters	Aerospace coatings application	Solvent-borne primer & topcoat application		Air Force Navy	
Limited Lifespan PPE	Aerospace coatings application	Solvent-borne primer & topcoat application		Air Force Navy	
Waste service rags; single-use cleaning items	Aerospace coatings application	Solvent-borne primer & topcoat application and cleanup		Air Force Navy	
Waste & expired organic coatings	Aerospace coatings application	Solvent-borne primer & topcoat storage and cleanup		Air Force Navy	
Waste solvent	Aerospace coatings application	Solvent-borne primer & topcoat cleanup		Air Force Navy	

1.3 REGULATORY DRIVERS

The current use of solvent-based chromated primers and topcoat compounds poses risks in the form of fines for non-compliance to federal, state, and local regulations. Fines may be imposed for violations related to the Clean Air and Clean Water Acts, National Emissions Standards for Hazardous Air Pollutants (NESHAP), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and Resource Conservation and Recovery Act (RCRA). Senior officials have recognized the increasing environmental demands placed on DoD facilities and have shown continued interest and support of demonstration/validation efforts which reduce dependence on traditional coating systems.

Volatile Organic Chemicals are defined by Title 40 of the Code of Federal Regulations (CFR) [40 CFR 51.100(s)] as any carbon-containing compound that participates in photochemical reactions, excluding those on the VOC-exempt compounds list. At room temperature these compounds typically evaporate at substantial rates and contribute to ground-level ozone (smog) formation. Documented short-term health effects of VOC exposure consist of headaches, loss of coordination, nausea, fatigue, eye, nose, and throat irritation. Long-term health concerns include kidney, liver, and central nervous system damage, and cancer formation.[1] Typically, state or local agencies only regulate VOC emissions for sources residing within ozone non-attainment areas, new facility construction, or major modifications to existing facilities.[2] Hazardous Air Pollutants are defined by the 1990 Clean Air Act (CAA) Amendments [Section 112(a)] as any air pollutant reasonably anticipated to adversely impact populations of species or degrade environmental quality, thus resulting in a need to establish emission limits. The short-term health effects of HAP exposure are similar to those experienced by exposure to VOCs. Long-term effects include birth defects, developmental delays, reduced ability of the immune system to fight diseases, and cancer formation.[3] Environmental Protection Agency (EPA)-regulated major sources, as defined by the CAA Amendments, encompass stationary sources nationwide that annually emit or have the potential to emit at least 10 tons of a single HAP or 25 tons of any combination of HAPs. Department of Defense rework and repair facilities commonly fall within this category.

Conventional paints include solvents, such as Methyl ethyl ketone (MEK) and Methyl isobutyl ketone (MIBK), which help dissolve or disperse the various paint components and ensure the desired consistency for application. The coatings release the majority of VOCs and HAPs during application of primers, and topcoats. Residual VOC/HAP releases continue as the coating system proceeds to full cure, and to a smaller extent throughout the coating's lifespan. Department of Defense coating applications are currently subject to NESHAP for Aerospace Manufacturing and Rework Facilities [40 CFR Part 63 Subpart GG]. In respect to solvent-based coatings, the NESHAP standards for primer and topcoat application operations [40 CFR 63.745] define the maximum allowable HAP and VOC content for both uncontrolled and controlled applications at aerospace rework facilities. These environmental constraints are of particular concern to defense facilities residing within non-attainment regions subject to fines for non-compliance with federal, state, and local environmental mandates.

The implementation of the OSHA Final Rule designating the permissible exposure limit (PEL) for hexavalent chromium is a significant driver for the use of non-chromium containing coatings. The employer must demonstrate that they have controls capable of keeping the OSHA eight-hour time weighted average to below 5.0 $\mu g/m^3$. The advantage of the LTCPC is that it replaces chromium use by eliminating chromium containing primers such as MIL-PRF-23377.

The LTCPC material has the ability to significantly mitigate the contributions to VOCs and HAPs for the solvent-based coating applications it replaces. It can also reduce the utilization of hexavalent chromium, by elimination of the primer process. This can all be accomplished without contributing to any new foreseen regulatory drivers.

2.0 DEMONSTRATION TECHNOLOGY

2.1 LTCPC DESCRIPTION

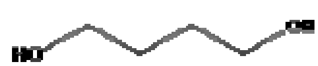
2.1.1 Basic Chemistry

Polymers can be placed into two main groups based on their behavior when heated: thermoplastics and thermosets. Thermoplastics are mainly composed of covalently-bonded, carbon-containing polymer chains that form weak Van der Waals bonds with adjacent chains to create three-dimensional lattices. The nature of Van der Waals bonding allows thermoplastics to be reshaped with the addition of heat to temporarily break these bonds. This ability contributes to widespread use of thermoplastics for recyclable packaging material. Thermosets are similar in composition to thermoplastics; however, thermosets exhibit covalent bonding that links the individual polymer chains into a three-dimensional lattice structure. This cross-linking of polymer chains prevents thermosets from being reshaped with the addition of heat. While thermosets are not easily reshaped, they do exhibit several desirable material characteristics such as:

- Increased material strength
- Increased thermal stability
- Insulating properties
- Lightweight composition
- Resistance to creep
- Reduced deformation under load

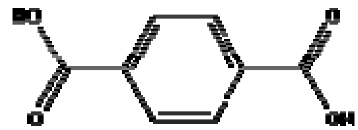
This program demonstrated an acid functional polyester resin combined with triglycidal isocyanurate (multifunctional epoxy cross-linker) for the purpose of delivering low temperature cure kinetics and exterior coating durability. This coating system utilized a thermosetting polymer that cures through the addition of energy. These reactions have the desirable characteristic of not producing any unwanted volatile byproducts. From a safety standpoint, the individual components comprising the LTCPC do not react with themselves. However care should be taken to avoid exposing the powder to any strong oxidizers, such as pure oxygen or peroxides, as they will initiate powder combustion.

The term "polyester" is standard nomenclature for a group of long-chained polymers assembled by the esterification condensation of multifunctional acids and alcohols. The family of multifunctional alcohols commonly selected for the thermoset polyesters of interest are glycols. Molecular compounds which are examples only but representatives of the individual components are presented in Figures 1 and 2.



[4]

Figure 1. Chemical Structure of a Dihydric Alcohol [1,4-Butanediol]



[4]

Figure 2. Chemical Structure of a Multifunctional Acid [Terephthalic Acid]

The acid and alcohol constituents are blended in the presence of heat and a catalyst to create a long-chained acid functional polyester resin. A representative example is found in Figure 3.

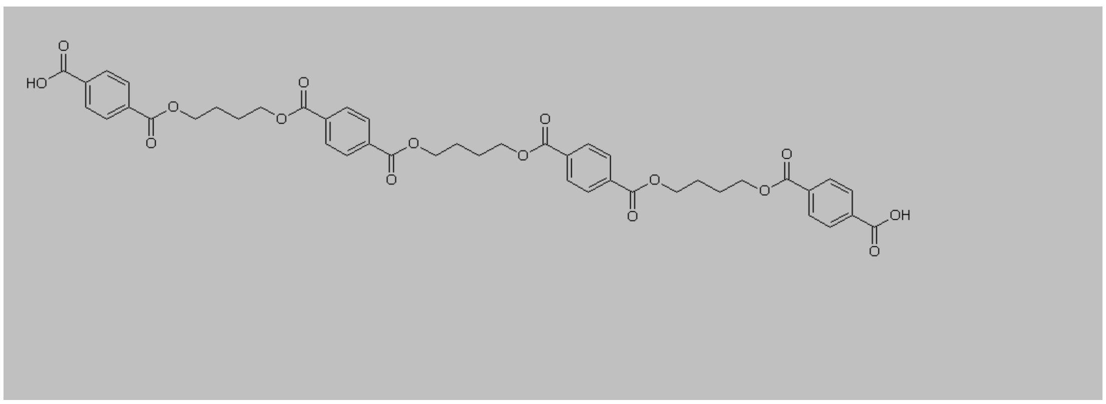
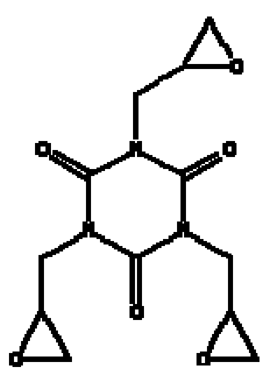


Figure 3. An Acid Functional Polyester Chain

The polyester resin is ground to a fine powder and then is blended with various additives including the multifunctional cross-linker (Figure 4) and pigments. This mixture is then melted at a low temperature together and extruded, then cooled and finally ground to a powder once again. It is this final mixture that is subsequently applied to the substrate surface as a powder coat. This powder coating is then subjected to heat during an oven curing stage. The associated reaction chemistry involves the epoxy curing agent bonding with multiple carboxyl groups to cross-link the various polyester chains, thus creating a three-dimensional lattice. Figure 5 illustrates the curing process resulting in a cross-linked polyester.



[4]

Figure 4. Chemical Structure of a Multifunctional Epoxy Cross-Linker [1,3,5-Triglycidyl Isocyanurate]

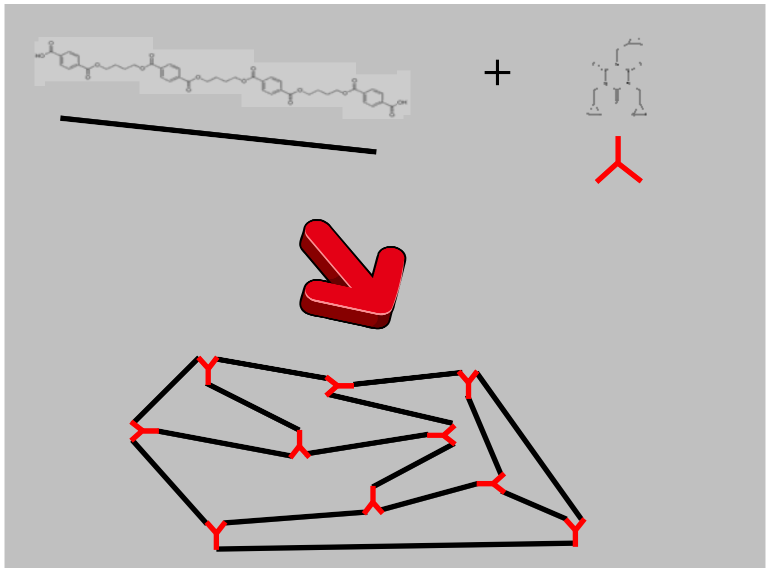


Figure 5. Cross-Linked Polyester Structure

2.1.2 Low Temperature Cure Mechanisms

Primarily, the temperature at which a thermosetting resin cures is a function of the cross-linker's chemical composition and cure rate is dependent upon the associated heat of reaction. To achieve a desired low cure temperature of 120°C, resin systems are selected which have a compatible curing point at or below this constraint while also fulfilling the desired material characteristics. Required heats of reaction can be decreased through the addition of low-concentration reaction catalysts (< 1.0 wt %) that greatly enhance the reaction rate at the desired cure temperature, and to a lesser extent by compatible corrosion inhibitor compounds.

2.1.3 Material Properties

For LTCPCs there were several required physical properties defined within the JTP. These requirements included a final coating thickness range, a minimum product shelf life, and finished surface quality. In addition to required physical properties, there were several material performance requirements a LTCPC candidate needed to meet. Performance with respect to the mechanical properties of coating adhesion, flexibility, impact resistance, and hardness needed to be satisfactory. The coating needed to display excellent corrosion resistance, to be evaluated by salt fog exposure, SO_2 exposure, cyclic corrosion for scribed substrates, and filiform corrosion testing. In addition, a LTCPC neeed to show a level of resistance to commonly used chemicals, such as MEK. The ESTCP effort was designed to demonstrate a low temperature cure powder that exhibited these properties.

2.1.4 Material Application

Ease of application is dramatically improved for powder coatings versus multistage primer/topcoat systems. There are four basic powder coating application processes: electrostatic spraying, fluidized bed, electrostatic fluidized bed, and flame spray. Electrostatic spraying was used for the purposes of this demonstration.

Figure 6 is an illustration of the steps required for electrostatic spraying. In electrostatic spraying, an electrical charge is applied to the dry powder particles while the component to be painted is electrically grounded. The charged powder and grounded workpiece create an electrostatic field that pulls the paint particles to the workpiece. The coating deposited on the workpiece retains its charge, which holds the powder to the workpiece. The coated workpiece is then placed in a curing oven, where the paint particles are melted onto the surface and the charge is dissipated.

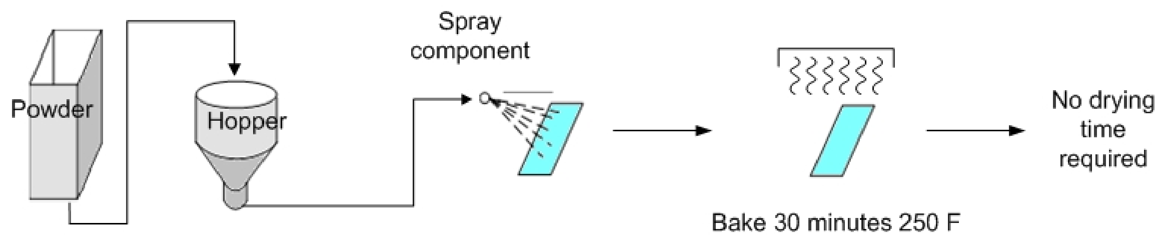


Figure 6. Process Illustration of Coating Process

2.1.5 Disposal

Accumulation of powder coating waste is made possible through localized waste stream collection and separation from any carrier material. Powder coating disposal is then accomplished by means of bulk storage container removal by contracted waste management carriers. Most powder coatings are not defined as hazardous waste, and as such do not require the level of documentation, reporting, and disposal costs normally associated with more conventional solvent-based coating systems. Avoidance of these disposal restrictions presents the potential for significant cost savings over the life cycle of identified service components. These savings were explored in greater detail later as part of the overall ESTCP program.

Recently the use of barium-containing compounds within coatings has raised concerns regarding appropriate characterization of worker exposure and risk. Testing based on EPA standards has proven that the level of barium metaborate present within the formulated LTCPC does not constitute a hazardous waste characteristic. As such, both the uncured and cured powder can be disposed of using methods for the disposal of non-hazardous waste.

2.2 LTCPC DEVELOPMENT

Beginning in Fiscal Year (FY) 2003, SERDP approved initial funding for an effort to identify and develop powder coating resins for corrosion protection of temperature-sensitive weapon system components. Initial design criteria for the low temperature cure powder coating candidate included an optimum cure temperature of 120°C (250°F) and a maximum cure time of 30 minutes. The optimum cure temperature was related to the highest temperature a substrate can withstand without modifying its material properties. It is detrimental to expose aluminum alloys used in components to temperatures above 160°C for prolonged periods as structural integrity of the metal may be compromised. Maximum cure time is largely driven by operational, logistical, and economical considerations. Military equipment is commonly measured in terms of its operational availability rate. In this regard, the more time a piece of equipment is unavailable due to tasks such as the application of coatings the lower the item's operational availability is. Above all else, a high level of unavailability has a negative impact on the military and its ability to accomplish a given mission. Of secondary concern is the fact that as time spent servicing an item increases, the associated labor costs increase as well. Efforts are continually made to identify processes or products that maximize the military's Operations and Maintenance (O&M) budget.

Under the leadership of Dr. Glen Merfeld, General Electric Global Research evaluated and optimized the formulation, and cure and performance parameters of candidate LTCPC materials under SERDP project PP-1268. Work began with the evaluation of several commercial powder coatings to meet the requirements necessary for use on military aircraft, weapons systems, and ground support equipment. The powder coating chemistries investigated included polyester/Primid, polyester/triglycidyl isocyanurate (PE/TGIC), epoxy, urethane, and acrylic resins. Various material tests were conducted through a government partnership of NAVAIR, Patuxent River, MD, the Air Force Research Laboratory (AFRL), Wright-Patterson AFB (WPAFB), OH, and the Department of Energy's (DOE) National Nuclear Security Administration (NNSA) Kansas City Plant, Kansas City, MO. The associated final report documenting the results of this effort, "120°C Cure, Durable, Corrosion Protection Powder Coatings for Temperature Sensitive Substrates" dated January 28, 2005, is available through the SERDP's publicly-accessible website (http://www.serdp.org).

2.3 ADVANTAGES AND LIMITATIONS OF LTCPC

The main advantages of low temperature cure powder coatings include the elimination of HAP and VOC content, as well as improved durability and corrosion resistance. Powders offer superior coating properties, so an inherent advantage is that primers are generally not required. Additionally, powder coatings are easier to prepare and apply in an application environment as there is no thinning, catalyst addition, mixing, or pot life issues to be concerned with.

A current limitation of powder coatings resides in the allowable humidity range for the application of powders, as humid conditions commonly promote clumping and degrade powder adherence to substrates. Also, complex shapes often create difficulties in achieving adequate coverage over all part areas as a result of Faraday Cage effects. The inability to cover large items effectively and size limitations imposed on qualified parts due to the curing oven's physical dimensions comprise two additional drawbacks of powder coating technology. Technology innovations such as Ultraviolet (UV) curable powders, which are not constrained by physical oven size due to their cure mechanism, may soon mature and compliment LTCPC by accommodating larger parts.

3.0 PERFORMANCE OBJECTIVES

There were a number of performance objectives evaluated over the course of this project. During the first phase of this demonstration/validation the LTCPC was subjected to both qualitative and quantitative product testing which validated the results of earlier SERDP testing. For the second phase of this project both services conducted field service evaluations after reviewing the results of LTCPC laboratory-scale testing.

Table 3. LTCPC Performance Objectives

Performance Objective	Data Requirements	Success Criteria	Results
Quantitative Performance Objectives			
Product Testing (JTP):			
• Color	• MIL-PRF-85285D, 4.6 FED-STD-595B ASTM D 2244	• ΔE < 1 from Federal Standard	• Not Reported (N/R)
• Gloss	• MIL-PRF-85285D, 4.6 FED-STD-595B ASTM D 523 (60° gloss)	• ≥ 90 gloss units (gloss coatings) $15 \leq \chi \leq 45$ gloss units (semi-gloss coatings)	• N/R
• Neutral Salt Fog Corrosion Resistance	• MIL-PRF-23377J, 4.5.8.1 ASTM B 117 ASTM D 1654	• No blistering or undercutting from the scribe after 2,000 hours	• **Inconclusive:** 2024-T3 Al **Passed criteria:** 6061-T6 Al; AZ31B Mg; 4130 Steel
• SO_2 Corrosion Resistance	• ASTM G 85, Annex A4 ASTM D 1654, Procedure A, Method 1	• No blistering or lifting after 500 hours	• **Failed criteria:** 2024-T3 Al **Inconclusive:** 6061-T6 Al **Passed criteria:** 4130 Steel
• Cyclic Corrosion Resistance	• GM 9540P GM 4465P ASTM D 1654 ASTM D 714 ASTM D 610	• No significant blistering, lifting, or softening of coating after 80 test cycles	• Passed criteria
• Filiform Corrosion Resistance	• MIL-PRF-23377J, 4.5.8.2 ASTM D 2803 ASTM D 1654	• ≤ 0.25 inch filaments from the scribe	• Passed criteria
• Cross-Cut Adhesion by Tape	• MIL-PRF-32239, 4.6.14 FED-STD-141D, Method 6301.3 ASTM D 3359, Test Method B	• 4B or better rating	• Passed criteria

Performance Objective	Data Requirements	Success Criteria	Results
• Impact Flexibility • Fluids Resistance • Low Temperature Flexibility	• MIL-PRF-85285D, 4.6.7.1 ASTM D 6905 • MIL-PRF-85285D, 4.6.8 • MIL-PRF-85285D, 4.6.7.2 ASTM D 522, Test Method B	• 5% or better elongation/area increase (Type II) • No blistering or loss of adhesion • No cracking over 1 inch mandrel @ -60°F	• Passed criteria • Passed criteria • Passed criteria
Field Service Evaluation: • Color • Gloss • Film Thickness • Corrosion	• FED-STD-595B ASTM D 2244 • FED-STD-595B ASTM D 523 (60° gloss) • ASTM D 7091 Measurements taken from at least six different points on the component • ASTM D 1654 Identify undercutting, pitting, or any required repairs	• Utilization of initial color swatches to determine amount of color change versus time • Determination of initial gloss and any change in gloss vs. time, especially for components exposed to outdoor conditions of sunlight, wind, and rain • Not Applicable (N/A) - record and report • No significant blistering, undercutting, or pitting of coating	• Inconclusive • Inconclusive • N/A • Passed criteria
Reduction of Hexavalent Chromium Use	Volume of: • Chromated primer usage	Elimination of chromate utilized by current process wet primer	Passed objective
Reduction of Hazardous Waste Generated	Volume of: • Raw materials usage • Air emissions filter usage • Disposable PPE usage • Single-use cleaning supply usage • Organic coatings	Elimination of hazardous waste generated by the current wet process	Passed objective

Performance Objective	Data Requirements	Success Criteria	Results
	waste • Spent cleaning solvent • Removed coatings		
Reduction of Processing Time Requirements	Tracking of processing time in demonstration	Reduction of processing time required for current wet process	Passed objective
Qualitative Performance Objectives			
Product Testing (JTP): • Coating Appearance • Strippability	• MIL-PRF-85285D, 4.6.3 • TO 1-1-8 AF Engineering Qualification Plan CLG-LP-043 Revision 0	• No visible coating or surface defects; Absence of micro-cracks at 10x magnification • N/A - record and report	• Passed criteria • N/A
Field Service Evaluation: • Coating Appearance • Adhesion • Fluids Resistance • Humidity Resistance	• Inspection of the coating for presence of visible surface defects • Determine coating adhesion after exposure to operational environments • Document occurrences of operational fluid exposures to coating • Document coating performance after long-term operational exposures to high	• Uniform smooth surface free from runs, sags, bubbles, streaks, hazing, seeding, dusting, mottling or other defects. Minimal to no orange peel shall be evident. • No visible lifting or flaking of coating • No visible blistering, softening, or other coating defects when and if encountered in the field • No visible blistering, softening, or loss of coating adhesion when and if	• Passed criteria • Passed criteria • Passed visual inspections • Passed visual inspections

Performance Objective	Data Requirements	Success Criteria	Results
	humidity	encountered in the field	
• Abrasion Resistance	• Document occurrences of coating abrasions during operational use	• Resistance to abrasion that equals or exceeds the baseline when and if encountered in the field	• Passed visual inspections
• Low Temperature Flexibility	• Inspection of the coating for presence of visible coating failure	• No visible cracking of the coating after exposure to low temperatures	• Passed criteria
Reduction of VOC/HAP Emissions	Volume of: • Raw materials usage • Cleaning solvent usage	VOC/HAP reductions from current process	Passed objective
Reduction of Rework Activities	Feedback from field technicians during demonstration	Reduced number of "no pass" component coating jobs currently experienced at the depot facilities from current process	Inconclusive
Reduction of Worker Exposures	Tracking of usage reductions in solvent-containing and chromated materials related to coating operations	Minimize worker exposure to VOCs, HAPs, and hexavalent chrome	Passed objective

3.1 QUANTITATIVE PERFORMANCE OBJECTIVES

3.1.1 Product Testing

3.1.1.1 Color and Gloss

The purpose of these performance objectives are to evaluate and compare the color and gloss of the LTCPC and control coating systems. Coating systems for weapon systems and support equipment must be able to meet specification requirements for color and gloss characteristics. For all color measurements, cured coating samples must produce a CIELAB color difference (ΔE) no greater than plus or minus one unit from the published federal color standard in FED-STD-595. Depending on the manufactured finish, a cured coating sample must register a minimum of 90 for "gloss" coatings or a reading between 15 and 45 for "semi-gloss" coatings when measured from a 60° angle of incidence. These tests utilized calibrated laboratory equipment to determine acceptable color and gloss characteristics.

3.1.1.2 Neutral Salt Fog Corrosion Resistance

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. Adequate salt fog corrosion inhibition exists if the cured coating demonstrates no blistering, lifting or substrate pitting after environmental exposure. Current coating specifications require that materials used on military equipment provide corrosion protection within a salt fog chamber for as much as 2,000 hours (MIL-PRF-23377J, Paragraph 3.8.2.1).

3.1.1.3 SO_2 Corrosion Resistance

SO_2 corrosion resistance relates to the ability of a coating system to prevent corrosion when exposed to corrosive conditions resulting from air pollutants. The test is similar to the neutral 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 naval vessels may be exposed to more aggressive atmospheres due to the presence and proximity of diesel engine stack fumes. Acceptable SO_2 corrosion resistance exists if the cured coating exhibits no blistering, pitting, or uplifting after exposure to sulfur dioxide acidified salt spray for 500 hours. Acceptable coatings prevent extensive corrosion in the area of the scribe and any corrosion extending from the scribe. Slight amounts of general surface corrosion are permitted within the scribe.

3.1.1.4 Cyclic Corrosion Resistance

Cyclic corrosion resistance testing evaluates the ability of coating systems to prevent corrosion when exposed to a simulated neutral pH corrosive environment. Scribed coated coupons are placed 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. Cured coatings provide an acceptable level of cyclic corrosion resistance when there is no significant blistering, lifting, or softening after exposure to 80 test cycles.

3.1.1.5 Filiform Corrosion Resistance

Filiform corrosion resistance 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 neutral salt fog resistance test and is required to ensure the candidate coating(s) provide the appropriate corrosion protection. This test is normally required for primers and not topcoats. However, as this project incorporated single coating systems (primerless), stakeholders included this test to ensure that a full comparison of the coating system properties occurred.

3.1.1.6 Cross-Cut Adhesion by Tape

The cross-cut adhesion by tape 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 agreed that adhesion testing was a performance requirement.

3.1.1.7 Impact Flexibility

The purpose of impact flexibility testing 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.

3.1.1.8 Fluids Resistance

Fluids resistance relates to the ability of a coating system to withstand exposure to fluids commonly encountered within an operational environment. It is a critical requirement that coating systems applied to military assets do not blister, soften, or otherwise fail to fully protect underlying substrates from sources of external damage. Laboratory fluids resistance testing was run per procedures outlined within MIL-PRF-85285D; *Coating: Polyurethane, Aircraft and Support Equipment*.

3.1.1.9 Low Temperature Flexibility

Low temperature flexibility testing relates to the ability of a coating system to maintain functionality at the low temperatures commonly encountered within aeronautical environments. Safety-of-flight concerns drive the requirement that coating systems applied to military assets retain adequate coating flexibility at lowered temperatures. Coating embrittlement can lead to failure propagation and potential coating adhesion failure. Laboratory low temperature flexibility testing was run per procedures outlined within ASTM D 522; *Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings*.

3.1.2 Field Service Evaluation

3.1.2.1 Color and Gloss

For an explanation of these performance objectives and their relevance to the demonstration please refer to Section 3.1.1.1.

3.1.2.2 Film Thickness

Measurement of the LTCPC dry film thickness is required to determine whether the coating remains within specification, thereby providing adequate protection of the substrate. During the

FSE dry film thickness measurements were taken from multiple locations along the component's surface and documented by either field technicians or project stakeholders.

3.1.2.3 Corrosion

For an explanation of this performance objective and its relevance to the demonstration please refer to Sections 3.1.1.2 through 3.1.1.5, which outline the corrosion categories of interest to LTCPC stakeholders during the FSE. Stakeholders assessed each component in the field for the presence of corrosion by means of unassisted visual inspections.

3.1.3 Reduction of Hexavalent Chromium Use

Hexavalent chrome has proven very adept at protecting sensitive substrates from corrosion; however it exposes the user to environmental, health, and safety risks. LTCPC's ability to provide adequate corrosion protection without the use of a chromated primer will be proven through laboratory-scale corrosion testing. Using a MIL-PRF-23377 primer as an example, the elimination of this primer at a nominal thickness of one mil results in the avoidance of approximately 3.9 pounds of strontium chromate per 1,000 square feet of painted surface area.

3.1.4 Reduction of Hazardous Waste Generated

A significant amount of hazardous waste is generated during the wet paint process. Handling, storage, and disposal of hazardous waste contributes to the overall labor and material costs associated with component maintenance. LTCPC's ability to reduce hazardous waste will be confirmed during the coating of FSE components. Based upon the wet coating MSDS sheets, use of LTCPC reduces as much as 30 pounds of solid waste as well as 6 pounds of volatile solvents per 1,000 square feet of painted surface area.

3.1.5 Reduction of Processing Time Requirements

Component processing time requirements are largely driven by the relatively long cure time requirements associated with wet coatings. LTCPC's ability to reduce overall processing time will be explored during the coating of FSE components. Transitioning to LTCPC saves an estimated 435 minutes per component versus applying wet coatings, which is based upon application and cure time data provided by facility stakeholders.

3.2 QUALITATIVE PERFORMANCE OBJECTIVES

3.2.1 Product Testing

3.2.1.1 Coating Appearance

The purpose of this performance objective 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. This test utilized both the unaided eye and minimal magnification to examine the coating for acceptable quality and appearance. This test was conducted to provide critical detailed evaluation of coating appearance and integrity. All participants agreed a surface appearance evaluation was necessary for this phase of the powder coating study.

3.2.1.2 Strippability

The purpose of this evaluation was 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). The ability to strip a coating off substrates is an important evaluation. Aircraft and ground support equipment components are required to occasionally remove their paint coatings for non destructive inspection and testing. During previous SERDP testing, a methylene chloride based stripper was successfully used on the LTCPC. This effort's evaluation was 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.

3.2.2 Field Service Evaluation

3.2.2.1 Coating Appearance

For an explanation of this performance objective and its relevance to the demonstration please refer to Section 3.2.1.1.

3.2.2.2 Adhesion

During the FSE any observed coating failures attributable to a deficiency in adhesion performance were documented by either field technicians or project stakeholders.

3.2.2.3 Fluids Resistance

For an explanation of this performance objective and its relevance to the demonstration please refer to Section 3.1.1.8. During the FSE any observed coating failures attributable to a deficiency in fluids resistance were documented by either field technicians or project stakeholders.

3.2.2.4 Humidity Resistance

Humidity resistance relates to the ability of a coating system to withstand exposure to the high levels of humidity commonly encountered within an operational environment. During the FSE any observed coating failures attributable to a deficiency in humidity resistance were documented by either field technicians or project stakeholders.

3.2.2.5 Abrasion Resistance

Abrasion resistance relates to the ability of a coating system to resist surface abrasions, which can compromise the integrity of coating and the substrate underneath. During the FSE any observed coating failures attributable to a deficiency in abrasion resistance were documented by either field technicians or project stakeholders.

3.2.2.6 Low Temperature Flexibility

For an explanation of this performance objective and its relevance to the demonstration please refer to Section 3.1.1.9. During the FSE any observed coating failures attributable to a deficiency in low temperature flexibility were documented by either field technicians or project stakeholders.

3.2.3 Reduction of VOC/HAP Emissions

Within the scope of this project, VOC and HAP emissions are largely tied to the application of wet coatings and solvents used to clean the spray equipment afterwards. LTCPC produces only trace levels of VOC or HAP emissions during application or curing. Additionally, only compressed air is needed to clean the associated powder coating equipment since raw LTCPC exists as an uncured, finely ground, non-adhesive solid. For an explanation of the reduction in volatile solvents please refer to Section 3.1.4.

3.2.4 Reduction of Rework Activities

Stakeholders originally selected to explore reductions in rework activities due to LTCPC's anticipated increase in coating durability. Visual comparison of the coating's durability against the baseline process provides the data necessary to evaluate this performance objective.

3.2.5 Reduction of Worker Exposures

The use of wet coatings exposes workers to several potential health and safety risks, such as hexavalent chrome and VOCs/HAPs. By its design, LTCPC eliminates the utilization of each of these items during coating operations. The MSDSs associated with each wet coating and LTCPC provides the information necessary to confirm the elimination of these health and safety risks.

4.0 SITES/PLATFORM DESCRIPTION

4.1 TEST PLATFORMS/FACILITIES

At the completion of qualification testing, full-scale field demonstration/field service evaluations (FSE) were accomplished. Field demonstrations spanned a minimum twelve-month period, starting with the application of the LTCPC onto candidate parts. Navy components were powder coated at Fleet Readiness Center Northwest or Southwest; while Air Force components were powder coated at the Ogden Air Logistics Center prior to installation on the associated weapons systems. Each of these FSE facilities were selected based upon the level of stakeholder buy-in related to LTCPC technology.

4.1.1 Fleet Readiness Center Northwest, NAS Whidbey Island, Washington

Before the US Navy's (USN) recent reorganization, Fleet Readiness Center Northwest (FRCNW) located at Naval Air Station (NAS) Whidbey Island was referred to as an Aircraft Intermediate Maintenance Department, providing intermediate and depot level aviation maintenance, component repair, and logistics support to the Fleet both locally and around the world. FRCNW provides a full range of aircraft avionics, armament, and electrical systems component repair that includes: J52 engine and component repair/build-up; T56-A-14 engine and component repair/build-up; flight control surface structural repair; aircraft canopy repair; P-3, EA-6B, and MH-60 aircraft tire/wheel repair; as well as aircraft Ground Support Equipment (GSE) repair.[5]

FRCNW's existing powder coating capability, along with a strong willingness to evaluate the LTCPC technology drove the decision to select this site as one of the demonstration's application facilities. In addition to their role as a LTCPC application facility, FRCNW also provided components suitable for field service evaluation.

4.1.2 Fleet Readiness Center Southwest, NAS North Island, California

Located on North Island, NAVAIR's Fleet Readiness Center Southwest (FRCSW), is the lead facility nationwide performing overhaul, repair and modification of the F/A-18 Hornet, including the E/F model Super Hornet. In addition to maintaining F/A-18 Hornets, FRCSW returns E-2 Hawkeyes, C-2 Greyhounds, multi-use S-3 Vikings, as well as H-60 Seahawk and AH-1/UH-1 helicopters to the fleet while providing over 60,000 aircraft component parts. The center is also the sole service site of the LM2500 turbine engine used to power Spruance-, Aegis- and Perry-class surface ships. FRCSW's component program boasts repair capability for over 35,000 unique components used on Navy and Marine frontline tactical and support aircraft for use by the depot's own programs and as critical parts for the Navy-wide supply system. Common avionics and support equipment are serviced by the depot as well. Additionally, Field Service and Voyage Repair teams work offsite worldwide to maintain aircraft and ship aviation support systems, bringing depot-level expertise and service to deployed units and to fleet units.[6]

FRCSW's existing powder coating capability, along with the willingness to evaluate the LTCPC technology drove the decision to select this site as one of the demonstration's application facilities. In addition to their role as a LTCPC application facility, FRCSW also provided components suitable for field service evaluation.

4.1.3 Ogden Air Logistics Center, Hill AFB, Utah

Ogden Air Logistics Center (OO-ALC) operates as one of AFMC's three depot maintenance facilities, with engineering, sustainment, and logistics management for USAF weapon systems including all Minuteman intercontinental ballistic missiles, F-16 fighters, Air Force and Marine Corps C-130 Hercules, as well as A-10 Thunderbolts. OO-ALC is the organization responsible for the management, overhaul, and repair of all types of landing gear, wheels, brakes, and tires. Ogden is also recognized as the Air Force Center of Industrial and Technical Excellence for low-observable, 'stealth', and aircraft structural composite materials. Additionally, maintenance activities associated with various USAF avionic, hydraulic, pneudraulic, and radar components, as well as instruments, gas turbine engines, power equipment systems, and special purpose vehicles occur at OO-ALC.[7]

OO-ALC's existing powder coating capability, along with the willingness to evaluate the LTCPC technology drove the decision to select this site as one of the demonstration's application facilities. In addition to their role as a LTCPC application facility, OO-ALC also provided components suitable for field service evaluation.

4.2 PRESENT OPERATIONS

Coatings currently in use on various non-flight critical components and ground support equipment are typically based upon a layered coatings approach. These coatings begin with substrate pretreatment, usually including a conversion coating (either a phosphate-type treatment for steel, or a chromated conversion coating for aluminum), to which a high-solids epoxy primer coating is applied (based on MIL-PRF-23377, MIL-P-53022, or MIL-P-53030), followed by a polyurethane topcoat (based on MIL-PRF-85285). Both the primer and topcoat are generally spray-applied. The conversion coating contributes to adhesion of subsequent coatings and provides limited corrosion resistance due to the hexavalent chromium content. The epoxy primer improves adhesion of the topcoat and offers excellent corrosion and chemical resistance while the topcoat typically provides the final finish color and appearance. The solvent-based coating process flow is displayed in Figure 7 while the resultant coating system is illustrated in Figure 8.

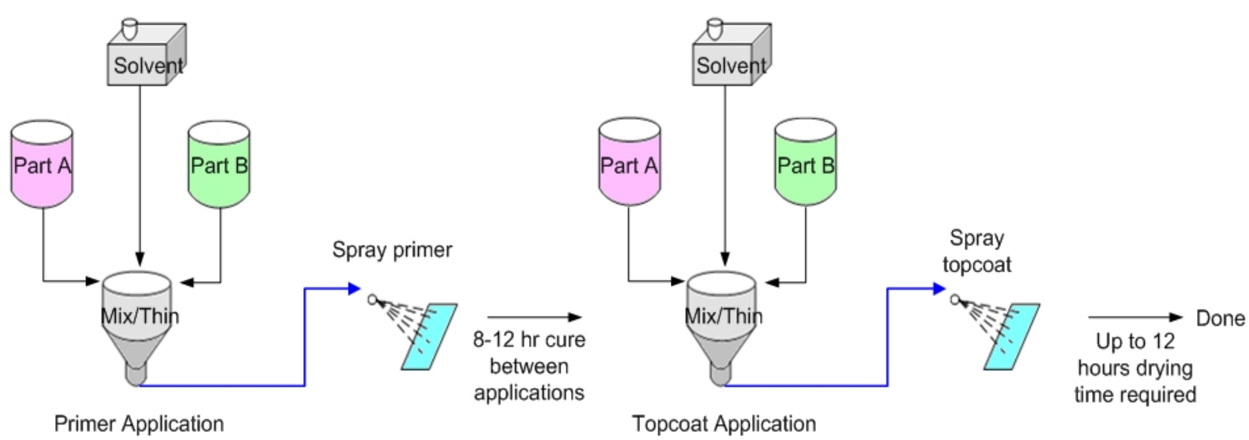


Figure 7. Conventional Solvent-Based Coating Process

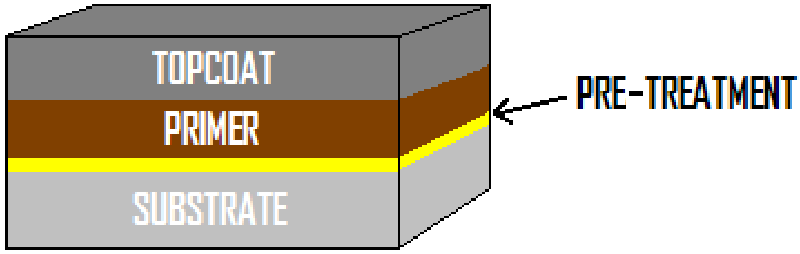


Figure 8. Typical Coating Stack-Up

Wet paint operations require the user to measure a quantity of paint for the task, combine the paint with appropriate components, mix to spray, and then apply. The user then must wait 8 to 12 hours before the next coat can be applied. Thus, significant labor costs and total process times can accumulate when multiple coating layers are required.

Material costs include the primer and topcoat kits, and solvents used for cleanup. For both the primer and topcoat materials, an additional cost impact arises from the fact that once the coating is mixed it begins to cure, whether or not it is applied to a part, and any material not applied within the allowable pot life must be disposed of. Additionally, there are the costs associated with paints exceeding their useful shelf life. Outdated and unused paint must be disposed of adding to hazardous waste costs, while at the same time, there are costs related to acquiring replacement inventory.

The environmental impacts of the solvent-based paint process result from the VOC and HAP contents and from the hexavalent chromium used as a corrosion inhibitor in most primers currently used.

4.2.1 USAF Coating Operations

4.2.1.1 Aircraft and Aircraft Components

Air Force maintenance actions related to aircraft and aircraft components are contained within general Technical Order (TO) 1-1-8, entitled "Application and Removal of Organic Coatings, Aerospace and Non-Aerospace Equipment". Current industrial coating processes associated with Air Force aircraft are documented within Chapters 4 through 6 and Appendix A of the TO.

The following coatings application topics comprising Chapters 4 through 6 and Appendix A of TO 1-1-8 are expected to be impacted by a transition to LTCPC:

- 4.2 Spray Methods
- 4.3 Spray Painting Equipment, General
- 4.4 Spray Painting
- 4.5 Cleaning and Maintenance
- 5.5 Aircraft Painting Operations
- 5.6 The Aircraft Painting Process Sequence of Events
- 5.7 Interior Finishing Procedures and Operations

5.8 Maintenance Painting
6.5 Preparation of Coating Materials for Use, General
6.6 Mixing and Thinning of Coating Materials, General
6.12 Coatings and Coating Systems

4.2.1.2 Support Equipment

Air Force maintenance actions related to support equipment are contained within general TO 35-1-3, entitled "Corrosion Prevention and Control, Cleaning, Painting, and Marking of USAF Support Equipment". Current industrial coating processes associated with Air Force aircraft are documented within Chapter 3 and Appendix A of the TO.

The following coatings application topics comprising Chapter 3 and Appendix A of TO 35-1-3 are expected to be impacted by a transition to LTCPC:

3.5 Authorized Colors, Sempens, and Materials
3.16 Coating Applications
A-1 Equipment and Consumable Materials

4.2.2 USN Coating Operations

4.2.2.1 Support Equipment

Naval maintenance actions related to support equipment are contained within NAVAIR TM 17-1-125, entitled "Maintenance Instructions; Organizational and Intermediate Level; Support Equipment Cleaning, Preservation, and Corrosion Control". Current industrial coating processes associated with support equipment are documented within Sections 7 and 8 of the TM.

The following coatings application topics comprising Sections 7 and 8 of NAVAIR 17-1-125 are expected to be impacted by a transition to LTCPC:

7-2 Recommended Coatings
7-5 Description of Powder Coating Systems
8-3 Health and Safety Precautions
8-4 Application Methods, Procedures, and Paint Equipment

4.3 SITE-RELATED PERMITS AND REGULATIONS

Powder coatings release very little if any VOCs and HAPs during application and curing. Additionally, the volume of solvent use associated with traditional wet coatings application and clean-up will be avoided, thereby reducing the overall amount of hazardous waste generated. Therefore the demonstration of LTCPC will not result in any additional permitting or regulation beyond what is currently in place at each location.

5.0 TEST DESIGN

5.1 JTP TESTING

5.1.1 Performance Testing Summary

Tables 4 and 5 summarize the common and extended performance testing that was conducted under the JTP and the subsequent JTP addendum.

Table 4. Common Performance and Testing Requirements

Engineering Requirement	Test	JTP Section	Acceptance Criteria	References
Critical detailed evaluation of coating appearance and integrity	Coating Appearance and Quality	4.1	Visible coating or surface defects. Presence of micro-cracks observable at 10X mag. Gloss and color retention.	MIL-PRF-85285D 4.6 & 4.6.3, FED-STD-595B, ASTM D 2244, ASTM D 523
Acceptable performance in aggressive salt water fog atmosphere	Neutral Salt Fog Corrosion Resistance	4.2	Degree of blistering, lifting, and/or substrate corrosion after 2000 hours	MIL-PRF-23377J 4.5.8.1, ASTM B 117, ASTM D 1654
Acceptable performance after exposure to varying/ cycling environments of salt fog, humidity and heat	Cyclic Corrosion Resistance	4.4	Degree of blistering, lifting, and/or substrate corrosion after 80 cycles	GM 9540P, GM 4465P, ASTM D 1654, ASTM D 610, ASTM D 714
Performance of coating system in an environment suitable for the formation of filiform corrosion	Filiform Corrosion Resistance	4.5	Measurement of corrosion filaments from scribe lines	MIL-PRF-23377J 4.5.8.2, ASTM D 1654, ASTM D 2803
Determine adequacy of intercoat and surface adhesion of organic coating	Cross-Cut Adhesion by Tape	4.6	Adhesion classification based on ASTM scale	MIL-PRF-32239 4.6.14, FED-STD-141D Method 6301.3, ASTM D 3359 Test Method B

Engineering Requirement	Test	JTP Section	Acceptance Criteria	References
Performance of coating when subjected to impact, and deformation of substrate	Impact Flexibility	4.7	Type II – 5%	MIL-PRF-85285D 4.6.7.1, ASTM D 6905
Determine the ability to remove the LTCPC from various substrates	Strippability	4.8	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
Performance of coating when subjected to commonly encountered service fluids	Fluids Resistance	JTR Appendix A.4	Visible coating or surface defects or failure modes after fluid immersion	MIL-PRF-85285D 4.6.8
Performance of coating when subjected to incidental material impact	Chipping Resistance	JTR Appendix A.5	Chipping resistance classification based on ASTM scale **(*)**	ASTM D 3170
Performance of coating when subjected to low temperatures	Low Temperature Flexibility	JTR Appendix A.6	Presence of surface cracking or failures observable with unaided eye	MIL-PRF-85285D 4.6.7.2, ASTM D 522 Test Method B

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

Table 5. Extended Performance and Testing Requirements

Engineering Requirement	Test	JTP Section	Acceptance Criteria	References	Participants Requiring Test
Acceptable performance in acidic corrosive environment	SO_2 Corrosion Resistance	4.3	Degree of blistering, lifting, and/or substrate corrosion after 500 hours.	ASTM G 85 Annex A4, ASTM D 1654 Procedure A Method 1	USN
Acceptable performance in aggressive salt water fog atmosphere	Neutral Salt Fog Corrosion Resistance on 7075 Aluminum	JTR Appendix A.1	Degree of blistering, lifting, and/or substrate corrosion after 2000 hours **(*)**	MIL-PRF-23377J 4.5.8.1, ASTM B 117, ASTM D 1654	NASA

Engineering Requirement	Test	JTP Section	Acceptance Criteria	References	Participants Requiring Test
Performance of coating when subjected to space-based temperature extremes	NASA Extreme Temperature Flexibility	JTR Appendix A.2	Presence of surface cracking or failures observable with unaided eye **(*)**	ASTM D 522 Test Method A	NASA
Vacuum stability of coating for use in spaceport applications	NASA Outgassing	JTR Appendix A.3	Measurement of percentage total mass loss and collected volatile condensable material **(*)**	ASTM E 595, NASA-STD-6001, SP-R-0022A Addendum 1	NASA

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

5.1.2 Test Preparation

This section contains information about materials and preparation common to most of the tests contained in the approved JTP and Appendix A of the subsequent JTR, with exceptions indicated where they occur. Test coupons are described in Table 6.

Table 6. 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 5.1.2.2.2 Controls prepared per Section 5.1.2.3.3
Al-2	2024-T3 Aluminum alloy (SAE AMS-QQ-A-250/4) 4 in. x 6 in. x 0.032 in.* Prepared per Section 5.1.2.2.1 Controls prepared per Section 5.1.2.3.1
Al-3	6061-T6 Aluminum alloy (SAE AMS-QQ-A-250/11) 4 in. x 6 in. x 0.032 in.* Prepared per Section 5.1.2.2.1 Controls prepared per Section 5.1.2.3.1
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 5.1.2.2.1 Controls prepared per Section 5.1.2.3.1 & 5.1.2.3.2
Al-5	7075-T6 Aluminum alloy (SAE AMS-QQ-A-250/12) 3 in. x 6 in. x 0.032 in. No surface preparation conducted No controls prepared

Test Coupon Code	Substrate Description
Al-6	2024-T3 Aluminum alloy (SAE AMS-QQ-A-250/4) 4 in. x 6 in. x 0.0625 in. No surface preparation conducted No controls prepared
Al-7	Pure Aluminum foil 2 in. x 2 in. x 0.005 in. No surface preparation conducted No controls prepared
Mg	AZ31B Magnesium alloy (SAE AMS-4375) 4 in. x 6 in. x 0.063 in.* Prepared per Section 5.1.2.2.3 Controls prepared per Section 5.1.2.3.4
ST	4130 Steel alloy (SAE AMS-6350) 4 in. x 6 in. x 0.032 in.* Prepared per Section 5.1.2.2.4 Controls prepared per Section 5.1.2.3.5

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

5.1.2.1 Coupon Preparation (General Requirements/All Coupons)

All coupons, except Al-1 coupons for Impact Flexibility Testing, were 4 in. x 6 in. x 0.032 in. Coupons for Impact Resistance Testing were 4 in. x 6 in. x 0.020 in. Refer to Appendix C for coupon quantities.

All test coupons were permanently identified using an indelible marker with unique coupon numbers traceable to control or test designation, alloy and heat treatment (e.g. using Test Coupon Codes from Table 6).

Subsequent to coating, all coupons designated for corrosion resistance testing were covered with tape on the back and edges to prevent corrosion products from contaminating the chamber**.**

5.1.2.2 Coupon Preparation (LTCPC Coupons)

For the Low Temperature Cure Powder Coat process, all aluminum coupons except the impact test coupons were prepared following the same procedure. Magnesium and Steel coupons each underwent a customized application processes.

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

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

Three coupons were coated with a chromate conversion coating conforming to MIL-C-5541 Class 1A; three coupons were not conversion coated for testing.

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

The low temperature cure powder coating was applied via gun to the face of each coupon. Final coating thickness, color and gloss were recorded.

5.1.2.2.2 Aluminum (For Impact Resistance Test)

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

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

The gloss white (color number 17925 per FED-STD-595B) low temperature cure powder coating was applied via gun to the face of each coupon. Final coating thickness was recorded.

5.1.2.2.3 Magnesium

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

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

The gloss white (color number 17925 per FED-STD-595B) low temperature cure powder coating was applied via gun to the face of each coupon. Final coating thickness was recorded.

5.1.2.2.4 Steel

Three steel (ST) coupons were pretreated with an iron phosphate pretreatment in accordance with TT-C-490E Type II and three panels were not pretreated. The gloss white (color number 17925 per FED-STD-595B) low temperature cure powder coating was applied via gun to the face of each coupon. Final coating thickness was recorded.

5.1.2.3 Coupon Preparation (Control Coupons)

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

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

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

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

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

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

MIL-PRF-85285D Topcoat (gloss white per FED-STD-595B, color number 17925) was spray applied in accordance with ASTM D 823 to a dry-film thickness of 1.7 – 2.3 mil. Coating was allowed 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.

5.1.2.3.2 Aluminum (For Validation of Filiform Corrosion Resistance Test)

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

One coat of MIL-C-8514 wash primer was spray applied and allowed to dry for no less than 30 minutes.

MIL-PRF-85285D Topcoat (gloss white per FED-STD-595B, color number 17925) was spray applied in accordance with ASTM D 823 to a dry-film thickness of 1.7 – 2.3 mil. Coating was allowed 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.

5.1.2.3.3 Aluminum (For Impact Resistance Test)

Al 2024-0 Temper (Al-1) coupons were anodized in accordance with MIL-A-8625, Type I. No primer was applied.

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

Topcoat was applied per MIL-PRF-85285D (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 was allowed to air dry at 68 - 77°F (20 - 25°C) for no less than 14 days prior to testing.

5.1.2.3.4 Magnesium

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

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

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

MIL-PRF-85285D Topcoat was spray applied in accordance with ASTM D 823 to a dry-film thickness of 1.7 – 2.3 mil. Coating was allowed 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.

5.1.2.3.5 Steel

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

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

MIL-PRF-85285D Topcoat was spray applied in accordance with ASTM D 823 to a dry-film thickness of 1.7 – 2.3 mil. Coating was allowed 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.

5.1.3 Initial JTP Test Procedures

The following sections describe tests included in the LTCPC project's approved JTP, provide rationale for inclusion, and specify procedures and parameters for individual tests.

5.1.3.1 Coating Appearance and Quality

Test Procedures

Prepare test coupons in accordance with Section 5.1.2.2.

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; *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 one when compared to the specified color in FED-STD-595B.

Gloss measurements shall be conducted on each coated coupon per ASTM D 523; *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.

Table 7. Coating Appearance and Quality 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 1/4 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

Major or Unique Equipment

- 10X optical magnifier
- Thickness gage

- Hunter Lab "Miniscan" Spectrophotometer (using CIELAB 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.
- Report average thickness readings taken at multiple locations across the panel's surface.
- Take digital photos of test coupons upon test completion.

Testing Organization and Location

- OO-ALC Science and Engineering Laboratory, Hill AFB, UT

5.1.3.2 Neutral Salt Fog Corrosion Resistance

Test Procedures

Operate the fog chamber for this test in accordance with ASTM B 117; *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 5.1.2.1, 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, 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.

Table 8. Neutral Salt Fog Corrosion Resistance 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 5.1.2.3
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.

Testing Organization and Location

- OO-ALC Science and Engineering Laboratory, Hill AFB, UT

5.1.3.3 SO_2 Corrosion Resistance

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, 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, 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

Table 9. SO_2 Corrosion Resistance 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 5.1.2.3
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, 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.

Testing Organization and Location

- NAVAIR Materials Engineering Laboratory, Patuxent River, MD

5.1.3.4 Cyclic Corrosion Resistance

Test Procedures

Tests shall be conducted on 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 10. Cyclic Corrosion Test Conditions

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

Table 11. 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, 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.

Table 12. Cyclic Corrosion Resistance 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 10 and 11.
Coupons Per Coating System	3 coupons each: Al-4 and ST LTCPC
Trials Per Coupon	One
Control Coupons Required	3 coupons each, coated with appropriate coating stack-up per Section 5.1.2.3
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.

Testing Organization and Location

- CTC Environmental Technology Facility, Johnstown, PA

5.1.3.5 Filiform Corrosion Resistance

Test Procedures

Tests shall be conducted as specified in ASTM D 2803; *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 5.1.2.3.2, 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, but not immersed, 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.

Table 13. Filiform Corrosion Resistance 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 5.1.2.3.1 3 coupons (Al-4), coated with wash primer and topcoat per Section 5.1.2.3.2
Acceptance Criteria	No filiform corrosion extending beyond ¼-inch from the scribe lines with the majority of filaments less than 1/8 –inch long.

<u>Major or Unique Equipment</u>

- Environmental (humidity) chamber
- Hermes engraver or equivalent

<u>Data Analysis and Reporting</u>

- 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.

<u>Testing Organization and Location</u>

- CTC Environmental Technology Facility, Johnstown, PA

5.1.3.6 Cross-Cut Adhesion by Tape

<u>Test Procedures</u>

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, 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, 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, Paragraph 12.9, and Figure 1, with the 0B to 5B rating. Provide digital photographs of each test coupon.

Table 14. Cross-Cut Adhesion by Tape Test Methodology

Parameters	ASTM D 3359 rating related to amount of coating removal
Coupons Per Coating System	6 each (3 pretreated, 3 non pretreated): Al-3 and ST 3 each: Mg LTCPC
Trials Per Coupon	One
Control Coupons Required	3 coupons each alloy, coated with appropriate coating stack-up per Section 5.1.2.3
Acceptance Criteria	Adhesion classification equal or greater than 4B as specified in ASTM D 3359 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, Test Method B.
- Take digital photos of test coupons prior to test initiation and upon test completion.

Testing Organization and Location

- OO-ALC Science and Engineering Laboratory, Hill AFB, UT

5.1.3.7 Impact Flexibility

Test Procedures

Prepare panels as directed in Sections 5.1.2.2.1 (test) and 5.1.2.3.3 (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, Table 1 for Percent Area Increase determination.

Table 15. Impact Flexibility Test Methodology

Parameters	Utilize GE Impact Tester or equivalent. Indenter: 3.6 lb.
Coupons Per Coating System	3 coupons Al-1 LTCPC
Trials Per Coupon	One
Control Coupons Required	3 Al-1 coupons, coated with appropriate coating stack-up per Section 5.1.2.3 and aged 14 days
Acceptance Criteria	≥ 5% elongation / area increase with no cracking

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.

Testing Organization and Location

- OO-ALC Science and Engineering Laboratory, Hill AFB, UT

5.1.3.8 Strippability

Test Procedures

Prepare panels as directed in Sections 5.1.2.2.1 and 5.1.2.3.1 (control). Control coupons shall be allowed to air-dry for no less than 14 days before testing.

For the chemical stripping evaluation, procedure CLG-LP-043 developed by the Air Force Coatings Technology 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 three coupons instead of the four mentioned in MIL-R-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.

Table 16. Chemical Strippability 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 5.1.2.3.2 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.

Table 17. Mechanical Strippability 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 5.1.2.3.2 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.

Major or Unique Equipment

- None

Data Analysis and Reporting

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

Testing Organization and Location

- OO-ALC Science and Engineering Laboratory, Hill AFB, UT

5.1.4 JTP Addendum Test Procedures

LTCPC stakeholders later identified several tests as special interest items, in addition to testing called out in the JTP. NASA stakeholders desired some performance evaluations not critical to other potential LTCPC users. NASA agreed to provide the substrate materials, perform most of the testing and share the results. The specimens were powder coated at Hill AFB concurrently with the JTP coupons.

In addition to the NASA tests, LTCPC team members determined that a few additional performance areas should be quantified. These areas were low temperature flexibility, fluid resistance, and impact/chipping resistance. Low temperature flexibility was performed by the Coatings Technology Integration Office at Wright-Patterson AFB on coupons coated at Hill AFB.

The LTCPC team became aware that fluid resistance and impact/chipping resistance evaluations had been performed under a separate study by the Navy. Rather than duplicate testing, the LTCPC team requested that data; their procedures and results are included in section Appendix E.

5.1.4.1 Neutral Salt Fog Corrosion Resistance on 7075 Aluminum

Description and Rationale

This test method evaluates a coating system's ability to prevent substrate corrosion within a humid salt-spray environment and the effect that any corrosion has on the adhesion of the coating system. Corrosion protection is a critical performance requirement of coating systems, as substrates are often corrosion sensitive and military equipment commonly operates in extreme environments. Humidity resistance testing shall be run per procedures outlined within MIL-PRF-23377J; *Primer Coatings: Epoxy, High-Solids* which references ASTM B 117; *Standard Practice for Operating Salt Spray (Fog) Apparatus*.

Test Preparation

Coupons for NASA's Salt Fog Corrosion testing shall ship directly to the powder coating facility and receive no on-site surface preparation. LTCPC application shall follow the procedures outlined in Section 5.1.2.2.1.

Test Procedures

Testing of NASA's Al 7075-T6 specimens shall parallel the test procedures found in Section 5.1.3.2.

Table 18. Neutral Salt Fog Corrosion Resistance on 7075 Al 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	Three coupons: Al-5 LTCPC
Trials Per Coupon	One
Control Coupons Required	None
Evaluation of Acceptability	No blistering or lifting after 2,000 hours. Slight substrate (0 to 1 rating) corrosion only.

Major or Unique Equipment

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

Data Analysis and Reporting

- Photograph and report the condition of the scribed area of the test coupons at 2,000 hours of testing or at failure, if less than 2,000 hours (along with exposure duration at failure)

Testing Organization and Location

- OO-ALC Science and Engineering Laboratory, Hill AFB, UT

5.1.4.2 NASA Extreme Temperature Flexibility

Description and Rationale

This test relates to the ability of a coating system to maintain functionality at the elevated and lowered temperatures commonly encountered within NASA's flight and space environments. Safety-of-flight concerns drive the requirement that coating systems applied to NASA assets retain adequate coating flexibility at both elevated and lowered temperatures. Coating embrittlement can lead to failure propagation and potential coating disbondment. The test shall be run per Rockwell Specification MB0125-055; *Primer, Epoxy Amine, Corrosion Room Preventative Room Temperature Curing*, dated January 6, 1997.

Test Preparation

Coupons for NASA's Extreme Temperature Flexibility testing shall ship directly to the powder coating facility and receive no on-site surface preparation. LTCPC application shall follow the procedures outlined in Section 5.1.2.2.1. Each control specimen shall be a LTCPC coupon that is not subjected to the temperature extreme being evaluated.

Test Procedures

Subject three coupons of Al 2024-T3 (3 x 6 x 1/16 inch) each to the bend test of ASTM D 522; *Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings* at -250 ± 10°F and +350 ± 10°F, except that a conical mandrel tapered from 1.3 to 0.9 inches in diameter shall be used.

Attachment of the coupons to the test fixture shall follow the setup procedures provided for Test Method A within ASTM D 522. Soak the bend test fixture and panels at temperature for 30 minutes prior to bending the specimen around the mandrel. Move the lever through 180° at uniform velocity to bend the test specimen, using a bend time of about one second to determine crack resistance. Examine the bent surface of the specimen immediately with the unaided eye for the presence of any cracking.

Table 19. NASA Extreme Temperature Flexibility Test Methodology

Parameters	Low Temp: Specimen and mandrel at –250 ± 10 °F for 30 minutes High Temp: Specimen and mandrel at +350 ± 10 °F for 50 hours. Panels cooled to room temp. Common: Bend panels around conical mandrel (1.3 to 0.9 in. taper). Traverse 180° bend arc over approx. one second.
Coupons Per Coating System	Eight coupons: Al-6 (3 tested at high temp; 3 tested at low temp; 2 to act as controls) LTCPC
Trials Per Coupon	One
Control Coupons Required	None
Evaluation of Acceptability	LTCPC exhibits no cracking

Major or Unique Equipment

- Conical mandrel bend test stand
- NASA mandrel (tapers from 1.3 to 0.9 inches)

Data Analysis and Reporting

- Photograph and report on the coated coupons' surface condition after being bent across the mandrel, noting the appearance of any surface cracking (failures)

Testing Organization and Location

- NASA Technology Evaluation for Environmental Risk Mitigation Principal Center, Kennedy Space Center, FL

5.1.4.3 NASA Outgassing

Description and Rationale

NASA's requirements for Outgassing are identified in NASA-STD-6001; Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion, dated February 9, 1998. The requirements for space use come from Johnson Space Center document SP-R-0022A, Addendum 1; General Specification Vacuum Stability Requirements of Polymeric Material for Spaceport Application, dated May 16, 1983.

The test shall be run per ASTM E 595; *Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials in a Vacuum Environment.*

Test Preparation

Aluminum foil test specimens (roughly 2 in. x 2 in.) shall receive all required surface treatments and be preweighed by NASA personnel before shipment to the LTCPC paint facility. Due to the nature of this test it is absolutely essential that specimen materials not be contaminated at any step in the specimen fabrication process. Test specimens **shall not** be handled with bare hands as natural skin oils are volatile and condensable, and thus will cause false test results. Suitable gloves or finger cots shall be used during all specimen preparation steps. The standard operating mode for this test dictates that all previously prepared materials are assumed to be contaminated in the "as-received" state and must be cleaned using a residue-free, non-reactive solvent.

LTCPC shall be applied via gun to the aluminum foil face. Final coating thickness shall be 0.002 – 0.004 in. (2 – 4 mils). Coating color shall be gloss white per FED-STD-595B, color number 17925.

Test Procedures

The test specimen is exposed to 23°C and 50% relative humidity for 24 hours in a preformed, degreased container (boat) that has been weighed. After this exposure, the boat and specimen are weighed and put in one of the specimen compartments in a copper heating bar that is part of the test apparatus. The vacuum chamber in which the heating bar and other parts of the test apparatus are placed is then sealed and evacuated to a vacuum of at least 7×10^{-3} Pa (5×10^{-5} torr). The heating bar is used to raise the specimen compartment temperature to 125°C. This causes vapor from the heated specimen to stream from the hole in the specimen compartment. A portion of the vapor passes into a collector chamber in which some vapor condenses on a previously-weighed and independently temperature-controlled, chromium-plated collector plate that is maintained at 25°C. After 24 hours, the test apparatus is cooled and the vacuum chamber is repressurized with a dry, inert gas. The specimen and the collector plates are weighed. From these results and the specimen mass determined before the vacuum exposure, the percentage Total Mass Loss (TML) and percentage Collected Volatile Condensable Material (CVCM) are obtained. Normally, the reported values are an average of the percentages obtained from three samples of the same material.

After the specimen has been weighed to determine the TML, the Water Vapor Regained (WVR) can be determined as follows: the specimen is stored for 24 hours at 23°C and 50% relative humidity to permit sorption of water vapor. The specimen mass after this exposure is determined. From these results and the specimen mass determined after vacuum exposure, the percentage WVR is obtained.

Table 20. NASA Outgassing Test Methodology

Parameters	Specimen at 23 °C & 50 % RH for 24 hours Apply vacuum to specimen chamber (≤ 7×10^{-3} Pa) within one hour Raise temp within one hour to 125 °C for 24 hours Collect vapor sample on plate maintained at 25 °C Cool specimen & equalize chamber pressure w/inert gas
Coupons Per Coating System	Eight coupons: Al-7 LTCPC
Trials Per Coupon	One
Control Coupons Required	None
Evaluation of Acceptability	TML ≤ 1.0 % CVCM ≤ 0.1 %

Major or Unique Equipment

- Vacuum bell
- Desiccators
- Heating bar
- Copper-based, multi-chambered outgassing apparatus with cover plates
- Chromium-plated collector plates
- Aluminum foil boats

Data Analysis and Reporting

- Report on the coated specimen's percentage of total mass loss and collected volatile condensable material

Testing Organization and Location

- Boeing Test Facility, Huntington Beach, CA

5.1.4.4 Low Temperature Flexibility

Test Preparation

Coupons for low temperature flexibility testing shall follow the preparation and application procedures previously outlined in Section 5.1.2.2.1. The control specimen shall be a LTCPC coupon that is not subjected to the low temperature exposure before testing.

Test Procedures

Attachment of the LTCPC panels to the test fixture shall follow the setup procedures provided for Test Method B within ASTM D 522. Subject the bend test fixture and coupons to the lowered temperature for four hours prior to bending the specimen around the mandrel.

Subject three coupons of Al 2024-T3 (3 x 6 x 1/16 inch) each to the cylindrical bend test of ASTM D 522; *Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings* at –60 ± 5°F.

Table 21. Low Temperature Flexibility Test Methodology

Parameters	Specimen and mandrel at –60 ± 5 °F for four hours Bend coupons around cylindrical mandrel (1 in. cylinder) Traverse 180° bend arc over approx. one second
Coupons Per Coating System	Four coupons: Al-2 (3 for testing; 1 to act as a control) LTCPC
Trials Per Coupon	One
Control Coupons Required	None
Acceptance Criteria	LTCPC exhibits no cracking

Major or Unique Equipment

- Cylindrical mandrel bend test stand

Data Analysis and Reporting

- Photograph and report on the coated surface's condition after the flexibility testing, noting the appearance of any surface cracking (failures).

Testing Organization and Location

- Coatings Technology Integration Office, Wright-Patterson AFB, OH

5.1.4.5 Low Temperature Flexibility

Test Preparation

Coupons for low temperature flexibility testing shall follow the preparation and application procedures previously outlined in Section 5.1.2.2.1. The control specimen shall be a LTCPC coupon that is not subjected to the low temperature exposure before testing.

Test Procedures

Attachment of the LTCPC panels to the test fixture shall follow the setup procedures provided for Test Method B within ASTM D 522. Subject the bend test fixture and coupons to the lowered temperature for four hours prior to bending the specimen around the mandrel.

Subject three coupons of Al 2024-T3 (3 x 6 x 1/16 inch) each to the cylindrical bend test of ASTM D 522; *Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings* at –60 ± 5°F.

Table 22. Low Temperature Flexibility Test Methodology

Parameters	Specimen and mandrel at –60 ± 5 °F for four hours Bend coupons around cylindrical mandrel (1 in. cylinder) Traverse 180° bend arc over approx. one second
Coupons Per Coating System	Four coupons: Al-2 (3 for testing; 1 to act as a control) LTCPC
Trials Per Coupon	One
Control Coupons Required	None
Acceptance Criteria	LTCPC exhibits no cracking

Major or Unique Equipment

- Cylindrical mandrel bend test stand

Data Analysis and Reporting

- Photograph and report on the coated surface's condition after the flexibility testing, noting the appearance of any surface cracking (failures).

Testing Organization and Location

- Coatings Technology Integration Office, Wright-Patterson AFB, OH

5.2 FIELD AND REAL-WORLD TESTING

Field service testing was performed on components that currently undergo solvent based coating applications. For the Air Force, complex shape application of LTCPC was demonstrated on the interior of C-130 wheel well doors. For the Navy, the LTCPC was applied to J52 aft engine yokes and NAN-4 nitrogen servicing carts. These components were subjected to a minimum 12 month FSE to demonstrate the coatings ability withstand the demanding and corrosive environment of US Navy aircraft carriers.

5.2.1 FSE Measurement and Monitoring

Initial color, gloss, and film thickness measurements were documented for each component prior to installation or return to inventory. LTCPC performance during the FSE was assessed via periodic measurement of the color, gloss, and film thickness for each article. For most FSE components evaluations were performed every six months. Where possible, a final measurement of color, gloss and film thickness was recorded at the completion of the FSE period for each component.

5.2.1.1 Color

Color measurements were taken from separate locations across each component's coated surface. During initial color readings the approximate locations of each measurement were documented on drawings by the observer, with the intention of attempting to record all subsequent color measurements from the same general areas. During the FSE, evaluators utilized a BYK-Gardner color meter for all color measurements.

5.2.1.2 Gloss

Gloss readings were taken from the same color measurement locations across each component's coated surface. During field inspection observers attempted to record all subsequent gloss measurements from the same general areas. During the FSE, evaluators used a BYK-Gardner gloss meter for all gloss measurements.

5.2.1.3 Film Thickness

Film thickness measurements were also taken from the same color measurement locations across each component's coated surface. During field inspection observers attempted to record all subsequent film thickness measurements from the same general areas. During the FSE, evaluators utilized a film gauge which was capable of handling both ferrous and non-ferrous metallic substrates for all film thickness measurements.

5.2.1.4 Surface Appearance

Over the course of the FSE, project stakeholders or field technicians completed qualitative inspections of each LTCPC surface for the appearance of any visible (unassisted eye) coating defects such as delamination, bubbling, or corrosion filaments.

6.0 PERFORMANCE ASSESSMENT

6.1 JTP TESTING

6.1.1 Assumptions and Deviations

In planning the coating and JTP procedures, some assumptions were utilized. Unlike many powder coating materials, the LTCPC contains a corrosion inhibitor, so it was determined that the final LTCPC system should perform satisfactorily without a primer (e.g., MIL-PRF-23377J, Primer Coatings: Epoxy, High-Solids). Therefore, the powder coated coupons prepared for JTP testing did not have a primer coating. Also, as coupons were not coated in a pristine laboratory environment, but in conditions simulating production processing, it was assumed that the powder coating performance would be weighed against the control coatings rather than strict specification performance thresholds.

6.1.1.1 Substrate Pretreatment

Aluminum Coupons

Panel preparation began with removing the oxidation layer using a nylon scouring pad with detergent and rinsing each one clean, so that a water break free surface was achieved. After completion of surface cleaning, an Alodine 1200S solution was poured onto the panel and worked into the surface using laboratory Kimwipes for approximately two minutes per side. The panels were then submerged in an Alodine bath for 15 minutes, removed and rinsed with deionized water, placed onto wire racks, and allowed to dry overnight.

Steel Coupons

Initially, steel test panels were prepared with an iron phosphate pretreatment. An iron phosphate line was not available at Hill AFB, so the coupons were shipped to a local Ogden, Utah vendor for pretreatment. During JTP testing, the steel coupons (both LTCPC and control coatings) failed prematurely. The cause was determined to be related to improper cleaning of the coupons prior to the iron phosphate treatment.

6.1.1.2 Coatings Application

Test coupons were powder coated at Hill AFB using the coating equipment and settings found in Table 23, while control specimens, with a conventional wet coating stack-up, were painted with a standard high volume, low pressure (HVLP) spray gun and allowed to cure for two weeks at room temperature..

Table 23. LTCPC Equipment and Settings

Gun System	Application Settings
ITW GEMA OptiFlex Electrostatic Powder Coating System (with fluidized bed powder hopper)	Air Pressure: 70 psi Powder Flow Rate: 3.0 lb/min Current: 15 μA Voltage: 80 kV

Powder coated coupons were cured in production-scale ovens currently in use at Hill AFB Power Systems Shop. Ovens were set to 250°F and allowed to reach equilibrium prior to coating and curing, but an anomaly was observed during the cure cycle for the initial set of coupons. Temperature measurements (using a *Fluke 62 Mini IR Thermometer,* which is a non-contact infrared, hand-held temperature sensor) indicated that panels placed at the rear of the oven showed an average surface temperature approaching 250°F while those panels near the front only registered a surface temperature of 230°F. This was attributed to the oven's inability to maintain a uniform temperature distribution at temperatures lower than 300°F. The oven set-point temperature was raised to 280°F to ensure that all LTCPC panels were fully cured after 30 minutes regardless of location within the oven (a cure temperature that isn't significantly greater than the target 250°F does not compromise the substrate or resultant coating). Following this adjustment, readings taken during the cure cycle confirmed a minimum surface temperature of 265°F for each of the panels.

A second issue presented itself after the magnesium panels were cured. Two of the coupons were found to have minor pinholes outside of the evaluation areas. It was later learned that the magnesium coupons had to be preheated prior to application of the power coat to minimize outgassing during the cure cycle.

6.1.2 Initial JTP

6.1.2.1 Coating Appearance and Quality

Coating appearance and quality were visually evaluated by coating personnel at Hill AFB. Coating thickness measurements were taken at nine locations across the panel's surface using a *PosiTector 6000 Series Coating Thickness Gage;* an *FN probe* was used to determine the average cured coating thickness of the steel panels and an *N probe* for the non-ferrous (aluminum and magnesium) panels.

For the evaluation of coating appearance and quality of the following substrate/coating system combinations were used. No major deviations from the expected appearance metrics were noted for the LTCPC panels.

Table 24. Coating Appearance and Quality Results

Coating System	Substrate	Pretreatment	Coupon 1	Coupon 2	Coupon 3
LTCPC	6061-T6	CCC*	No defects	No defects	No defects
	AZ31B	Dow 7	No defects	No defects	No defects
	4130	Mn phosphate	No defects	No defects	No defects

* Chromate Conversion Coating

= Unacceptable test result

= Marginal test result

= Acceptable test result

Table 25. Coating Thickness Measurements

Coating System	Substrate	Pretreatment	3 Coupon Average Thickness
LTCPC	2024-T3	CCC*	2.5 mils
		none	3.1 mils
	2024-T3 Alclad	CCC	1.7 mils
		none	2.1 mils
	6061-T6	CCC	1.8 mils
		PreKote	2.3 mils
	6060-T6	CCC	1.8 mils
		none	2.0 mils
	AZ31B	Dow 7	2.0 mils
		Dow 7 / PreKote	1.9 mils
		none	2.1 mils
	4130	none	1.7 mils
MIL-PRF-23377 / MIL-PRF-85285	2024-T3	CCC	3.0 mils
	6061-T6	CCC	2.2 mils
	6060-T6	CCC	2.5 mils
	AZ31B	Dow 7	2.3 mils
MIL-PRF-85285	2024-T3 Alclad	none	3.1 mils

* Chromate Conversion Coating

Coating appearance and quality for LTCPC coupons equaled those of the control coating stack-ups. Each of the prepared aluminum, steel, and magnesium specimens met the acceptance criteria for coating appearance and thickness as defined within the LTCPC JTP.

6.1.2.2 Neutral Salt Fog Corrosion Resistance

Neutral salt fog testing was performed on 2024 and 6061 aluminum, steel and magnesium substrates. The 2,000 hour test was performed using an *Auto Technology Model CCT-NC-30 Cyclic Corrosion Test Chamber* operating within their laboratory facilities at Hill AFB.

For neutral salt fog corrosion resistance, results demonstrated that most coupons met the program's corrosion resistance requirement for exposure to salt spray environments.

Table 26. Neutral Salt Fog Corrosion Resistance Results

Coating System	Substrate	Pretreatment	Coupon 1	Coupon 2	Coupon 3
LTCPC	2024-T3	CCC*	2000+ hrs corrosion oxides	2000+ hrs corrosion oxides	2000+ hrs corrosion oxides
		none	2000 hrs blistering	2000 hrs blistering	2000 hrs blistering
	6061-T6	CCC	3300+ hrs no blistering	3300+ hrs no blistering	3300+ hrs no blistering
		PreKote	3300+ hrs no blistering	3300+ hrs no blistering	3300+ hrs no blistering
	6060-T6	CCC	2000+ hrs 2 discrete blisters	2000+ hrs 1 discrete blister	2000+ hrs 2 discrete blisters
		none	2000 hrs no blistering	2000 hrs blistering	2000 hrs blistering
	AZ31B	Dow 7	2000 hrs no blistering	2000 hrs no blistering	2000 hrs no blistering
	4130	Mn phosphate	1600 hrs red rust	1600 hrs red rust	1600 hrs red rust
MIL-PRF-23377 / MIL-PRF-85285	2024-T3	CCC	2000+ hrs corrosion oxides	2000+ hrs corrosion oxides	2000+ hrs corrosion oxides
	6061-T6	CCC	2000+ hrs no blistering	2000+ hrs no blistering	2000+ hrs no blistering
	6060-T6	CCC	2000+ hrs no blistering	2000+ hrs no blistering	2000+ hrs no blistering
	AZ31B	Dow 7	2000 hrs blistering	2000 hrs blistering	2000 hrs Blistering
MIL-P-53022 / MIL-PRF-85285	4130	Mn phosphate	1600 hrs red rust	1600 hrs red rust	1600 hrs red rust

* Chromate Conversion Coating

(pink) = Unacceptable test result

(yellow) = Marginal test result

(green) = Acceptable test result

Figures 9 through 16 are of the test coupons following the neutral salt fog corrosion resistance testing.

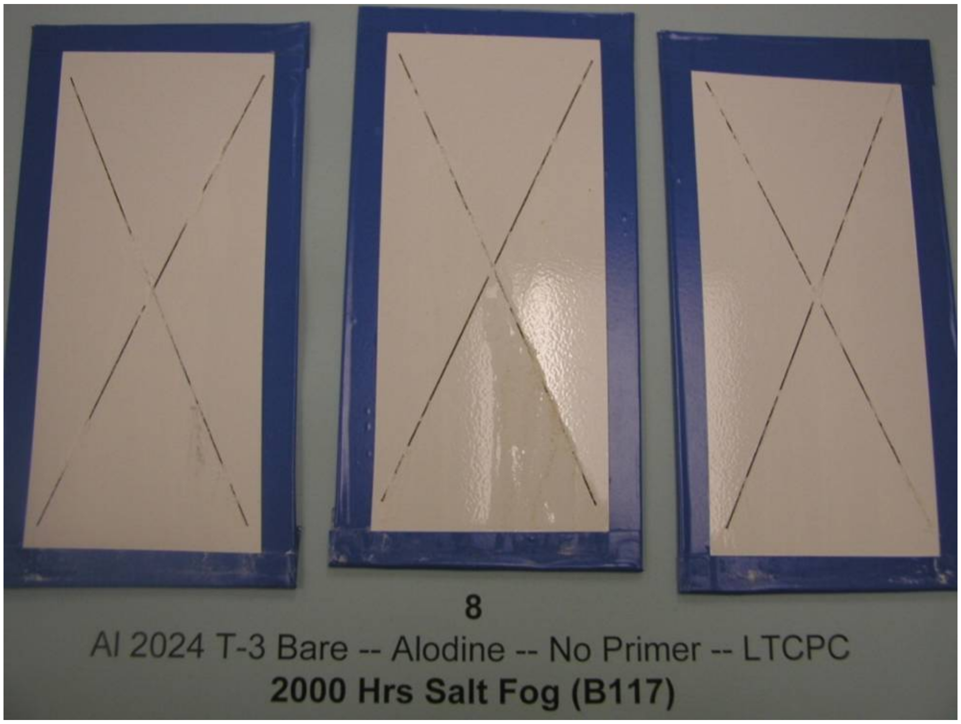


Figure 9. LTCPC Neutral Salt Fog Test Outcome – 2024 Al

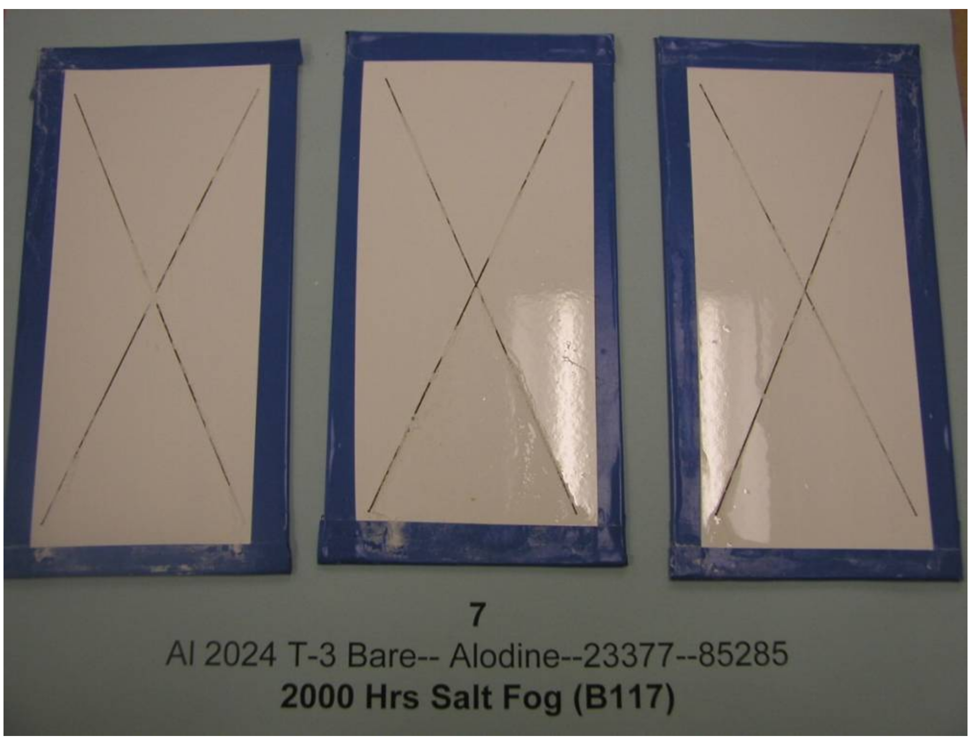


Figure 10. Control Coating Neutral Salt Fog Test Outcome – 2024 Al

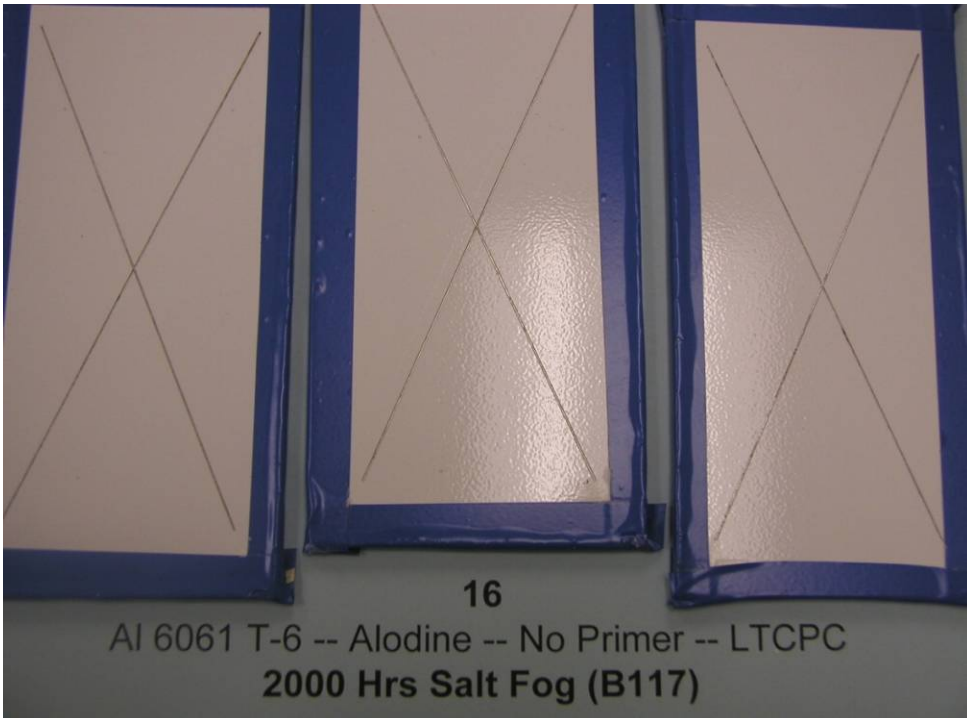


Figure 11. LTCPC Neutral Salt Fog Test Outcome – 6061 Al

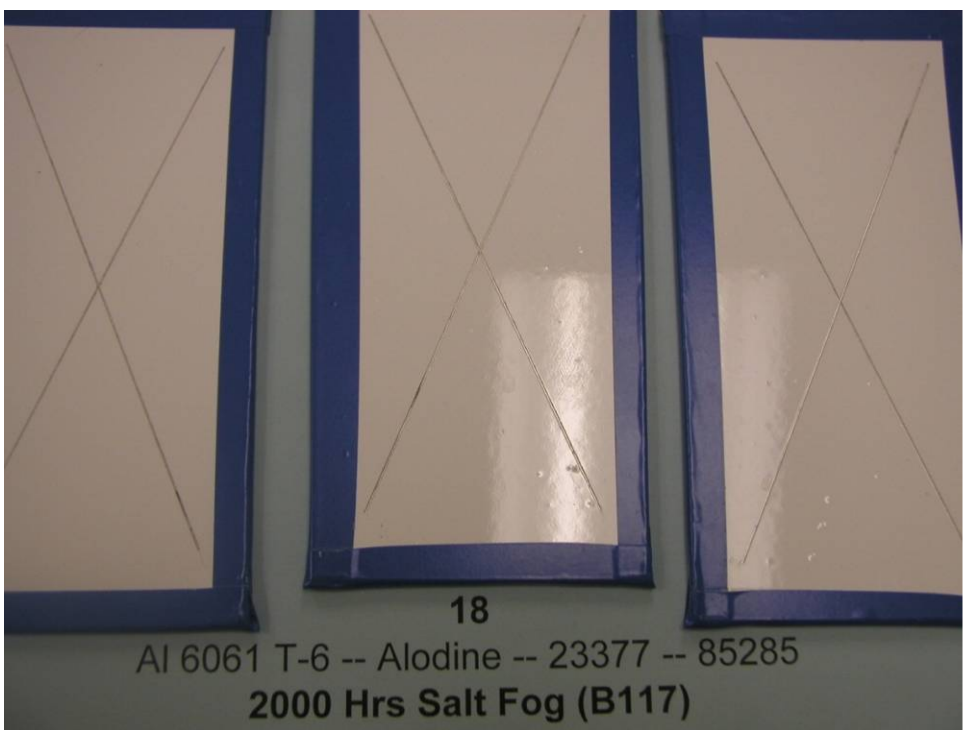


Figure 12. Control Coating Neutral Salt Fog Test Outcome – 6061 Al

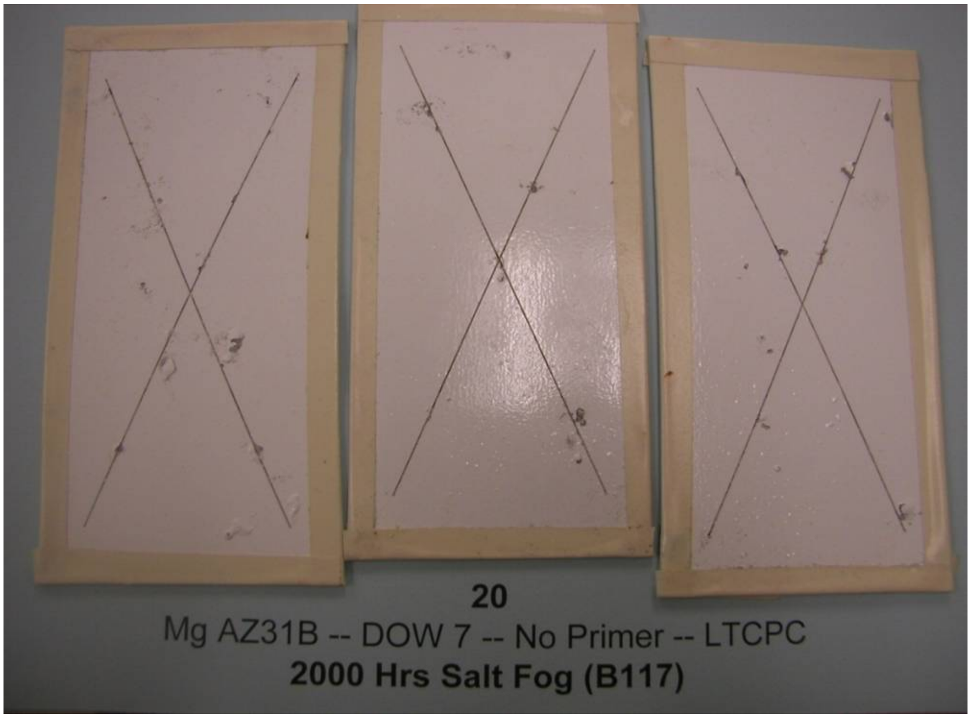


Figure 13. LTCPC Neutral Salt Fog Test Outcome – AZ31B Mg

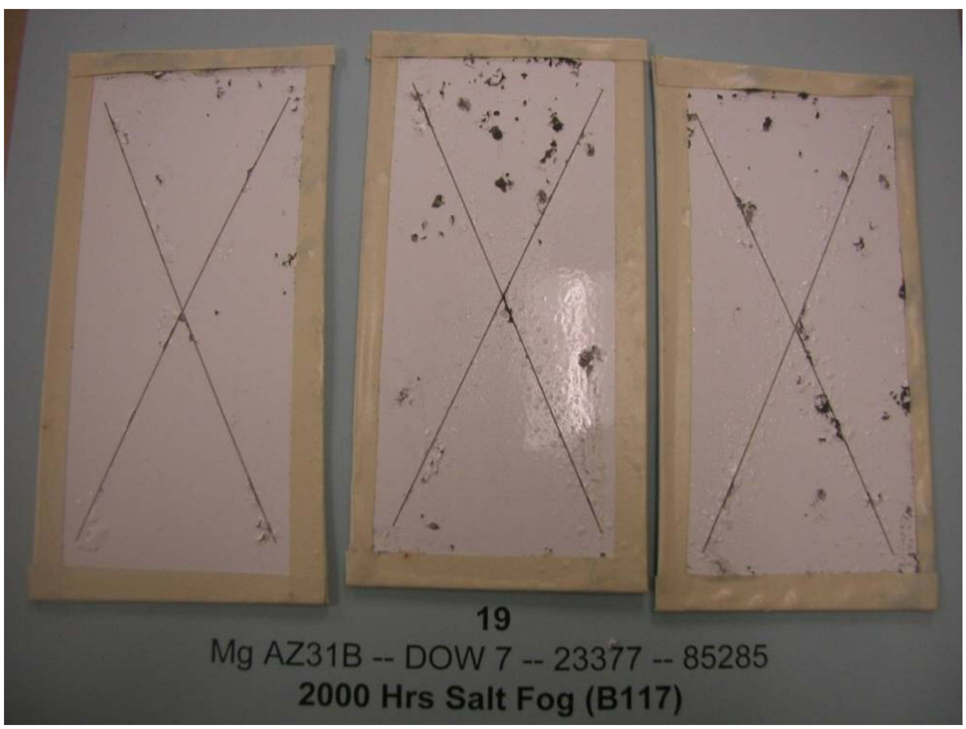


Figure 14. Control Coating Neutral Salt Fog Test Outcome – AZ31B Mg

Figure 15. LTCPC Neutral Salt Fog Test Outcome – Steel

Figure 16. Control Coating Neutral Salt Fog Test Outcome – Steel

Neutral salt fog corrosion resistance test results confirmed that LTCPC performs in a similar fashion as the baseline coating stack-ups when both are prepared and tested in a production-like environment. All of the Alodined aluminum coupons (both LTCPC and conventional wet coating) passed inspection after 2,000 hours of exposure inside the salt fog corrosion chamber. Non-pretreated aluminum coupons generally failed to meet the corrosion resistance criteria as defined within the JTP, exhibiting unacceptable blistering of the coatings near the scribed areas (however, on a relative basis the non-pretreated LTCPC coupons displayed less blistering than the similar non-pretreated controls). These test results demonstrate the need for a chromate conversion coating (CCC) or comparable pretreatment process to be in place for aluminum substrates regardless of which coating stack-up is used.

Testing also demonstrated that LTCPC performance on Dow 7-treated, LTCPC coated magnesium coupons paralleled the performance of controls covered with conventional coating systems.

Both the LTCPC and control-coated steel specimens failed to meet ideal performance requirements even with a manganese phosphate pretreatment, however LTCPC's performance was equivalent to the control stack-up. As with the other two substrates, steel LTCPC coupons displayed a level of corrosion resistance similar to that shown by the conventional wet coating.

6.1.2.3 SO_2 Corrosion Resistance

The Navy's Patuxent River facility completed SO_2 corrosion resistance testing using a modified *Auto Technology Model GS-SCH #23 Salt Fog Test Chamber*. 2024 and 6061 aluminum and 4130 steel received 500 hours of exposure to an SO_2 atmosphere for this test.

Table 27 lists substrate/coating system combinations that underwent SO_2 corrosion resistance testing. While both the steel and pretreated 2024-T3 aluminum coupons passed SO_2 corrosion resistance testing, the remainder failed to meet the Navy's requirement.

Table 27. SO_2 Corrosion Resistance Results

Coating System	Substrate	Pretreatment	Coupon 1	Coupon 2	Coupon 3
LTCPC	2024-T3	CCC*	500 hrs Minor blistering	500 hrs Minor blistering	500 hrs Minor blistering
		none	500 hrs blistering	500 hrs blistering	500 hrs blistering
	6061-T6	CCC	500 hrs blistering	500 hrs blistering	500 hrs blistering
		PreKote	500 hrs blistering	500 hrs blistering	500 hrs blistering
	6060-T6	CCC	500 hrs blistering	500 hrs blistering	500 hrs blistering
		none	500 hrs blistering	500 hrs blistering	500 hrs blistering
	4130	Mn phosphate	500 hrs no blistering	500 hrs no blistering	500 hrs no blistering
MIL-PRF-23377 / MIL-PRF-85285	2024-T3	CCC	500 hrs no blistering	500 hrs no blistering	500 hrs no blistering
	6061-T6	CCC	500 hrs blistering	500 hrs blistering	500 hrs blistering
	6060-T6	CCC	500 hrs blistering	500 hrs blistering	500 hrs blistering
MIL-P-53022 / MIL-PRF-85285	4130	Mn phosphate	500 hrs no blistering	500 hrs no blistering	500 hrs no blistering

* Chromate Conversion Coating

(pink) = Unacceptable test result

(yellow) = Marginal test result

(green) = Acceptable test result

Figures 17 through 22 are of the test coupons following the SO_2 corrosion resistance testing.

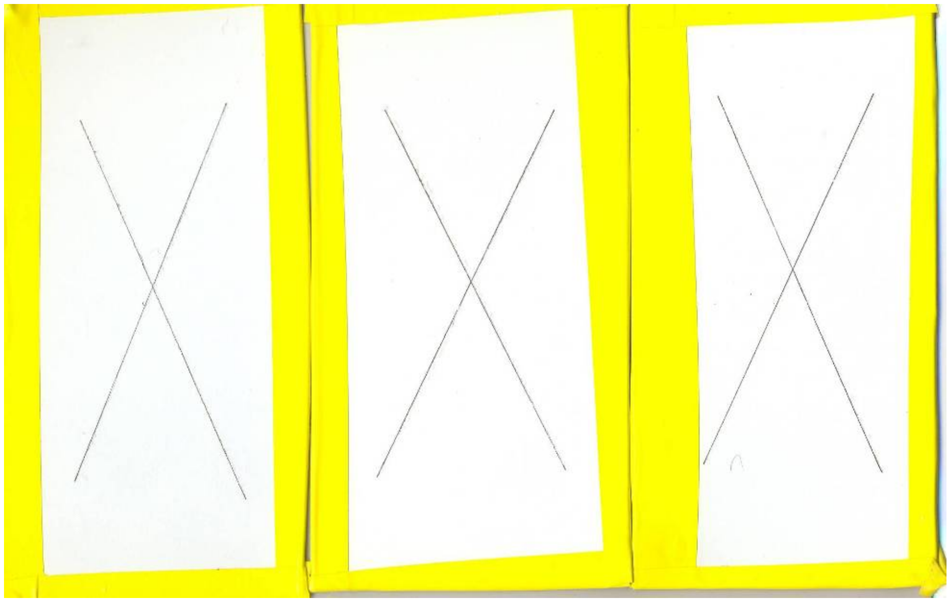


Figure 17. LTCPC SO_2 Corrosion Resistance Test Outcome – 2024 Al

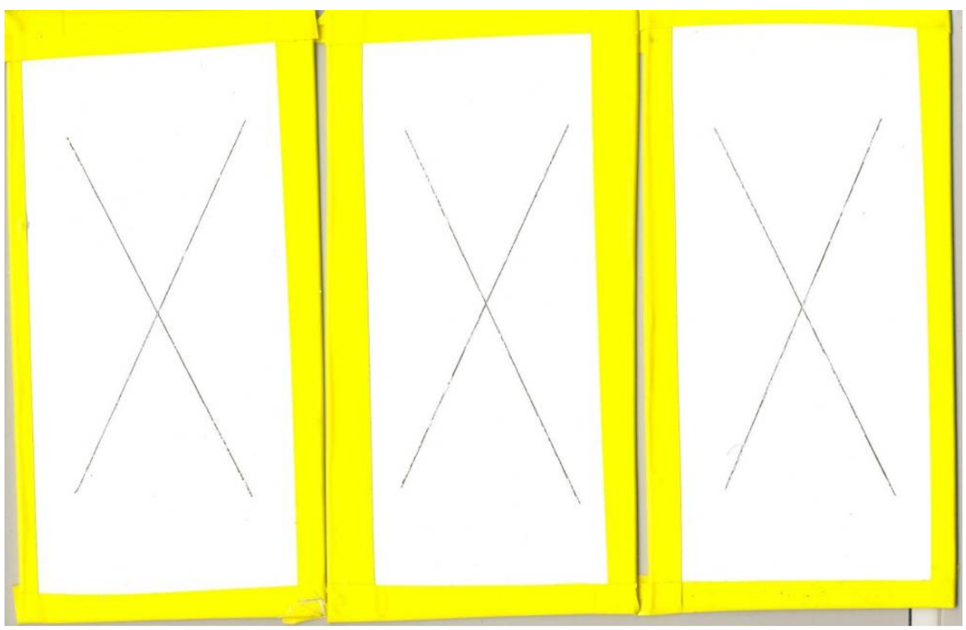


Figure 18. Control Coating SO_2 Corrosion Resistance Test Outcome – 2024 Al

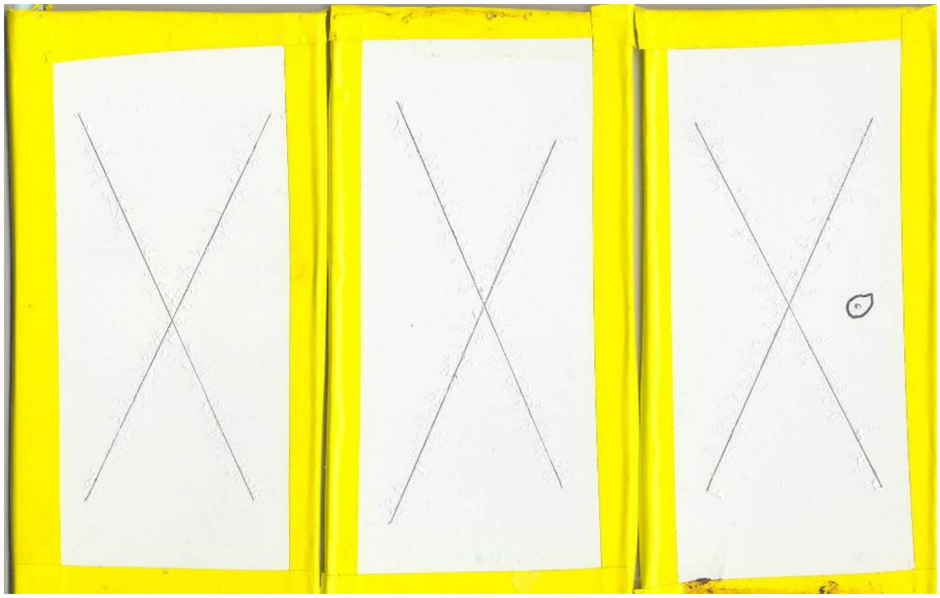


Figure 19. LTCPC SO_2 Corrosion Resistance Test Outcome – 6061 Al

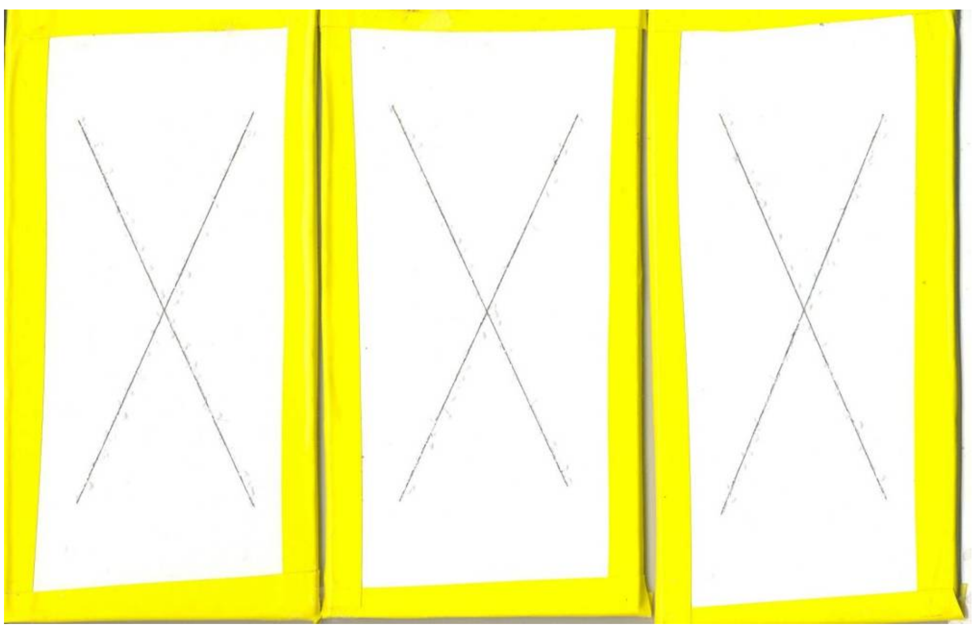


Figure 20. Control Coating SO_2 Corrosion Resistance Test Outcome – 6061 Al

Figure 21. LTCPC SO_2 Corrosion Resistance Test Outcome – Steel

Figure 22. Control Coating SO_2 Corrosion Resistance Test Outcome – Steel

SO_2 corrosion resistance test results confirmed that LTCPC performs in a similar fashion as the baseline coating stack-ups when prepared and tested in a production-like environment. Evaluation of the selected aluminum coupons resulted in acceptable SO_2 corrosion resistance (as defined by the JTP) for only the Alodined 2024-T3 LTCPC and control-coated coupons. All remaining aluminum specimens suffered major blistering near the scribed regions. Stakeholder discussion produced a consensus that poor surface pretreatment was likely to blame for the test failures of low copper content aluminum alloys while the 2024-T3 specimens passed. From a comparative standpoint the LTCPC-coated Al coupons for each group matched the performance of the baseline coatings. For the 4130 steel substrate, all specimens passed 500 hours of SO_2 exposure. Side-by-side comparison of the steel test coupons reveals that LTCPC's resistance to SO_2-based corrosion equals that of the control stack-up.

6.1.2.4 Cyclic Corrosion Resistance

Coupons for cyclic corrosion resistance were shipped from Hill AFB to CTC in Johnstown, PA for testing. CTC utilized a *Q-Fog Model CCT 1100 Cyclic Corrosion Test Chamber* that conformed to General Motors specification GM 9540P; *Accelerated Corrosion Test*, dated June 1997 to evaluate both aluminum and steel panels. For each 24-hour cycle the test specimens were subjected to four iterations of a salt mist application and ambient dwell (combined time eight hours), followed by an eight hour exposure to high humidity and an eight hour drying period. Eighty 24-hour test cycles were completed. Test specimens were inspected after completion the first four and first eight test cycles, followed by every eighth cycle thereafter (16, 24, 32, etc.) through test completion. Performance was rated using the methods outlined within Procedure B of ASTM D 1654; *Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments.*

Cyclic corrosion resistance testing was performed on the substrate/coating system combinations listed in Table 28.

Table 28. Cyclic Corrosion Resistance Results

Coating System	Substrate	Pretreatment	Coupon 1	Coupon 2	Coupon 3
Scribed Area – Average Overall Creepage Rating					
LTCPC	2024-T3 Alclad	CCC*	9	9	9
		none	9	9	8
	4130	Mn phosphate	6	7	6
MIL-PRF-23377 / MIL-PRF-85285	2024-T3 Alclad	none	9	8	8
MIL-P-53022 / MIL-PRF-85285	4130	Mn phosphate	7	7	8
Scribed Area – Overall Interval of Noticeable Adhesion Loss/Corrosion (hours)					
LTCPC	2024-T3 Alclad	CCC	1174 – 1339	1339 – 1771	624 – 937
		none	383 – 624	624 – 937	0 – 196
	4130	Mn phosphate	185 – 576	185 – 576	185 – 576
MIL-PRF-23377 / MIL-PRF-85285	2024-T3 Alclad	none	0 – 196	196 – 383	956 – 1174
MIL-P-53022 / MIL-PRF-85285	4130	Mn phosphate	744 – 984	744 – 984	185 – 576
Unscribed Area – Average Overall Failure Percentage Rating					
LTCPC	2024-T3 Alclad	CCC	10	10	10
		none	10	10	10
	4130	Mn phosphate	10	9	9
MIL-PRF-23377 / MIL-PRF-85285	2024-T3 Alclad	none	10	9	10
MIL-P-53022 / MIL-PRF-85285	4130	Mn phosphate	10	9	10
Unscribed Area – Overall Interval of Noticeable Red Rust/Corrosion (hours)					
LTCPC	2024-T3 Alclad	CCC	NC**	NC	NC
		none	NC	NC	NC
	4130	Mn phosphate	NC	576 – 744 blistering; red rust	744 – 984 blistering; red rust
MIL-PRF-23377 / MIL-PRF-85285	2024-T3 Alclad	none	NC	954 – 1174 blistering	NC
MIL-P-53022 / MIL-PRF-85285	4130	Mn phosphate	NC	0 – 185 red rust	NC

* Chromate Conversion Coating
** No Corrosion

= Unacceptable test result
= Marginal test result
= Acceptable test result

Tables 30 and 31 (from ASTM D 1654) outline both the scribed and un-scribed area failure ratings for cyclic corrosion resistance testing.

Table 29. Scribed Failure Rating

Representative Mean Creepage From Scribe		
Millimetres	Inches (Approximate)	Rating Number
Zero	0	10
Over 0 to 0.5	0 to 1/64	9
Over 0.5 to 1.0	1/64 to 1/32	8
Over 1.0 to 2.0	1/32 to 1/16	7
Over 2.0 to 3.0	1/16 to 1/8	6
Over 3.0 to 5.0	1/8 to 3/16	5
Over 5.0 to 7.0	3/16 to 1/4	4
Over 7.0 to 10.0	1/4 to 3/8	3
Over 10.0 to 13.0	3/8 to 1/2	2
Over 13.0 to 16.0	1/2 to 5/8	1
Over 16.0 to more	5/8 to more	0

Table 30. Unscribed Area Failure Rating

Area Failed, %	Rating Number
No failure	10
0 to 1	9
2 to 3	8
4 to 6	7
7 to 10	6
11 to 20	5
21 to 30	4
31 to 40	3
41 to 55	2
56 to 75	1
Over 75	0

Figures 23 through 26 are of the test coupons following the cyclic corrosion resistance testing.

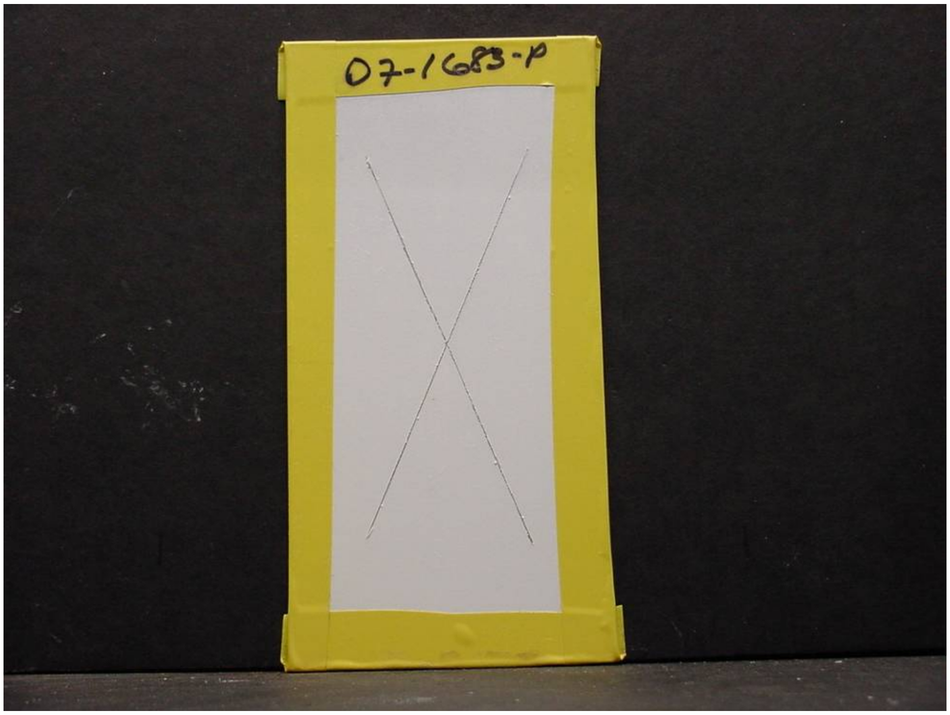


Figure 23. LTCPC Cyclic Corrosion Resistance Test Outcome – Aluminum

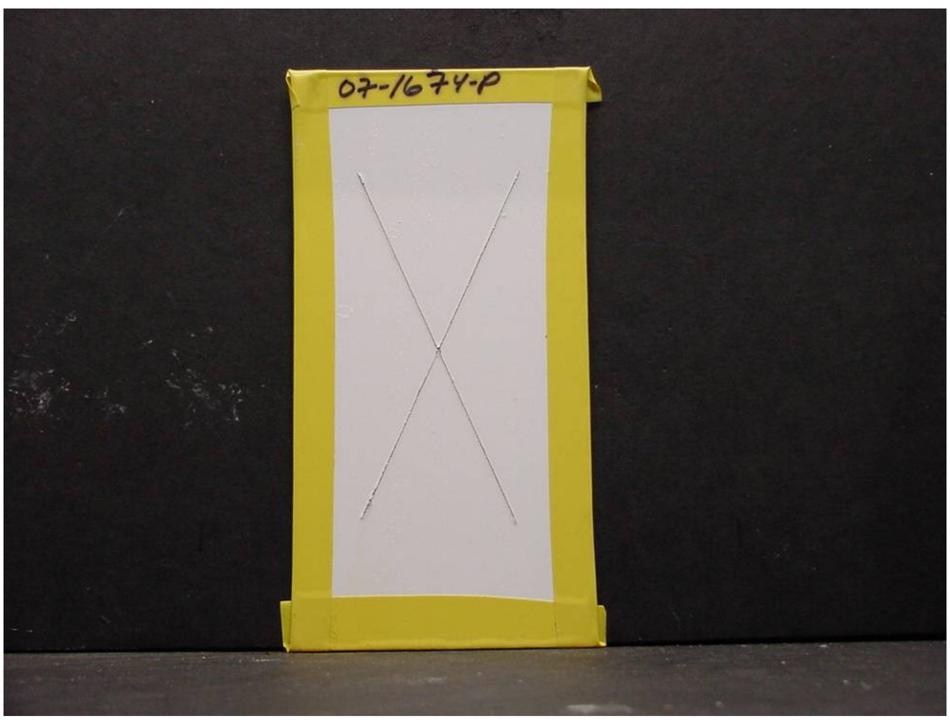


Figure 24. Control Coating Cyclic Corrosion Resistance Test Outcome – Aluminum

Figure 25. LTCPC Cyclic Corrosion Resistance Test Outcome – Steel

Figure 26. Control Coating Cyclic Corrosion Resistance Test Outcome – Steel

Overall cyclic corrosion resistance test results confirmed that LTCPC performs in a similar fashion as the baseline coating stack-ups when prepared and tested in a production-like environment. The Alodined 2024-T3 Alclad coupons outperformed the baseline MIL-PRF-

85285 aluminum counterparts, while non-pretreated Alclad coupons exhibited equivalent corrosion resistance with regards to the scribed and unscribed area creepage/failure ratings. On average the LTCPC coupons survived exposure to cyclic corrosion for a longer period of time before displaying the first signs of adhesion loss. Mean time to noticeable adhesion loss for the three Alodined LTCPC specimens was 1,046 hours and 336 hours for the set of non-pretreated LTCPC coupons. The trio of aluminum controls had a mean time to noticeable adhesion loss of 384 hours which is reasonably equivalent to the average of the non-pretreated LTCPC coupons. Also LTCPC on manganese phosphate treated steel coupons responded to cyclic corrosion in a manner similar to that of the comparable baseline primer and topcoat combination. Ratings and post-test photographs revealed the levels of blistering and red rust for the steel controls were as pronounced as the LTCPC coupons.

6.1.2.5 Filiform Corrosion Resistance

Filiform corrosion resistance testing was also performed by CTC. Per standard procedures, scribed coupons were exposed to 12N hydrochloric acid for one hour inside an airtight desiccator. The coupons were then immediately placed inside a *Singleton Model CCT-10P Cyclic Programmable Humidity Chamber* capable of maintaining a relative humidity of 80% ± 5% and an elevated temperature of 104 °F ± 3 °F over a period of 1,000 hours. The coupons were visually examined for filament growth at the scribe.

In the initial round of filiform testing, no conventional wet coating coupons were submitted as controls. This was problematic as the LTCPC performance did not meet specification requirements (had control coupons been available, performance comparable or better than controls would have been considered acceptable). A second set of LTCPC coated clad aluminum panels were prepared, in conjunction with conventional wet coating stack-up control coupons. Filiform corrosion resistance test results generated from the second set of coupons are reported below.

CTC was provided a second group of coupons, along with control coupons representing a conventional coating system. Results of the retest revealed that both LTCPC and the control stack-up provided acceptable resistance. From a comparative standpoint LTCPC performed as well as the control coating stack-up with regards to filiform corrosion resistance. Individually, two of the LTCPC coupons passed with acceptable test results while a third coupon was marginal (maximum filament length exceeded by 1/32") as defined within the JTP. The three control coupons produced very similar test results, limiting maximum filament length to 1/16" for each article. Results from the retest coupons are presented within the following table.

Table 31. Subsequent Filiform Corrosion Resistance Results

Coating System	Substrate	Pretreatment	Coupon 1	Coupon 2	Coupon 3
Number of filaments					
LTCPC	2024-T3 Alclad	CCC*	TNTC**	TNTC	TNTC
MIL-PRF-23377 / MIL-PRF-85285	2024-T3 Alclad	CCC	118	114	97
Min/Max length of filaments from scribe (inches)					
LTCPC	2024-T3 Alclad	CCC	1/32 7/32	1/32 9/32	1/32 1/8
MIL-PRF-23377 / MIL-PRF-85285	2024-T3 Alclad	CCC	1/32 1/16	1/32 1/16	1/32 1/16

* Chromate Conversion Coating
** Too Numerous To Count
= Unacceptable test result (pink)
= Marginal test result (yellow)
= Acceptable test result (green)

Figures 27 and 28 are photos of the test coupons following the filiform corrosion resistance retest.

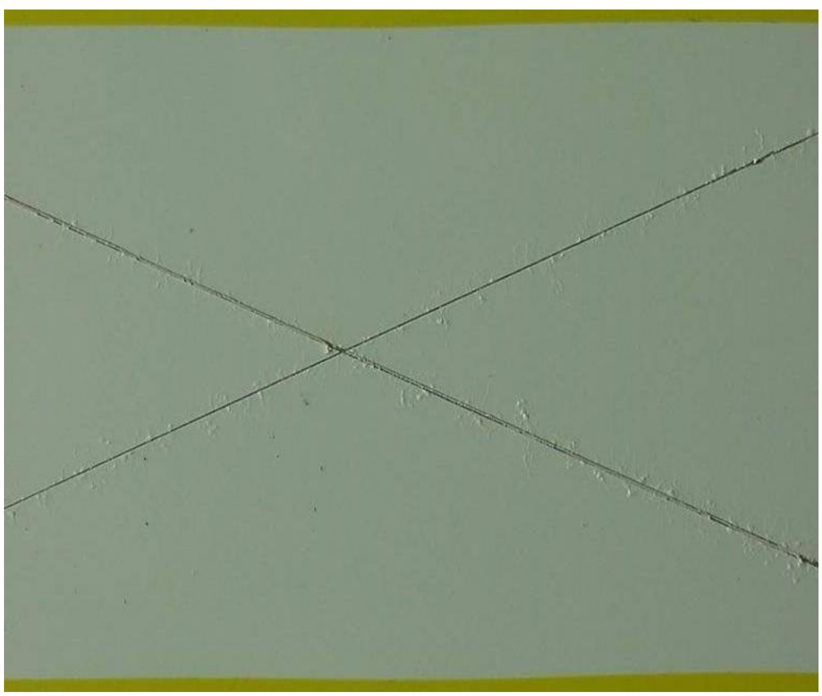


Figure 27. LTCPC Filiform Corrosion Resistance Test Outcome – Retest

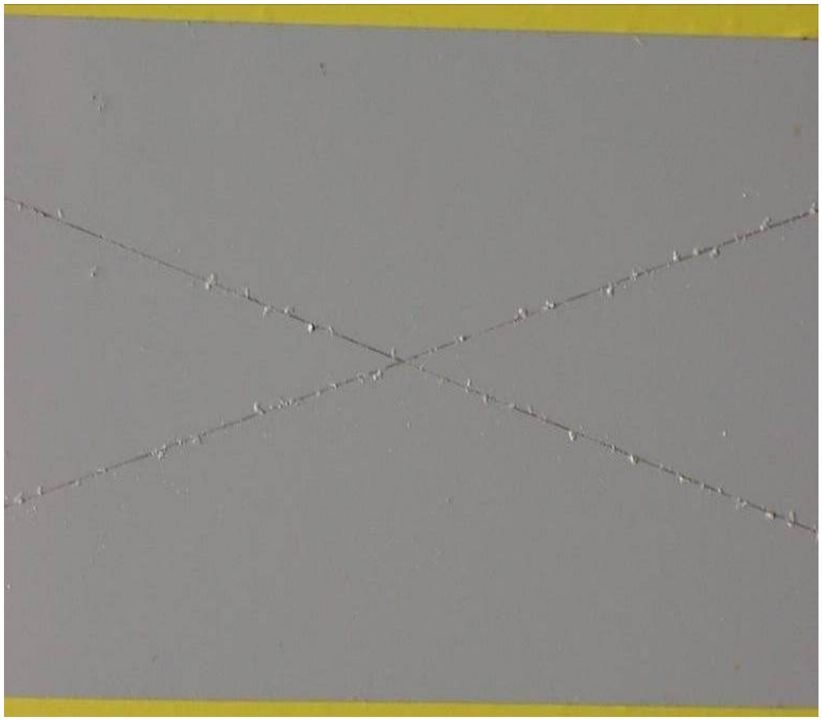


Figure 28. Control Coating Filiform Corrosion Resistance Test Outcome - Retest

6.1.2.6 Cross-Cut Adhesion by Tape

An *eight-blade circular cutting tool* with two millimeter offsets was used to scribe two sets of lines, at 90° angles to one another and each approximately 3/4 inches in length, as required for the cross-cut adhesion by tape test. Wet tape adhesion was performed on aluminum and steel substrates and dry tape adhesion was performed on the magnesium coupons, with all tests being run at Hill AFB.

Cross-cut adhesion by tape testing was performed on the following substrate/coating system combinations. Each of the scribed coupons confirmed adequate coating adhesion to the substrate.

Table 32. Cross-Cut Adhesion by Tape Results

Coating System	Substrate	Pretreatment	Adhesion
LTCPC	2024-T3	CCC*	5B
		none	1B
	2024-T3 Alclad	CCC	5B
		none	4B
	6061-T6	CCC	5B
		PreKote	5B
	6060-T6	CCC	5B
		none	5B
	4130	Fe phosphate**	5B
			5B
		none	5B
			2B†
	AZ31B	Dow 7	5B
		Dow 7 / PreKote	5B
		none	3B
MIL-PRF-23377 / MIL-PRF-85285	2024-T3	CCC	5B
	6061-T6	CCC	5B
	6060-T6	CCC	5B
	AZ31B	Dow 7	5B
MIL-P-53022 / MIL-PRF-85285	4130	Fe phosphate**	5B
			4B
MIL-PRF-85285	2024-T3 Alclad	none	0B

* Chromate Conversion Coating
** Tested prior to changeover to manganese phosphate pretreatment of steel
† Statistical outlier with failure attributable to surface preparation deficiencies
(pink) = Unacceptable test result
(yellow) = Marginal test result
(green) = Acceptable test result

Table 33 (derived from ASTM D 3359) outlines the relationship between adhesion ratings and the percentage of coating area removed is provided for convenience.

Table 33. Cross-Cut Adhesion Coating Removal Classifications

Classification	Percent Area Removed
5B	0 %
4B	< 5 %
3B	5 – 15 %
2B	15 – 35 %
1B	35 – 65 %
0B	> 65 %

Figures 29 and 30 are of the test coupons following the cross-cut adhesion testing.

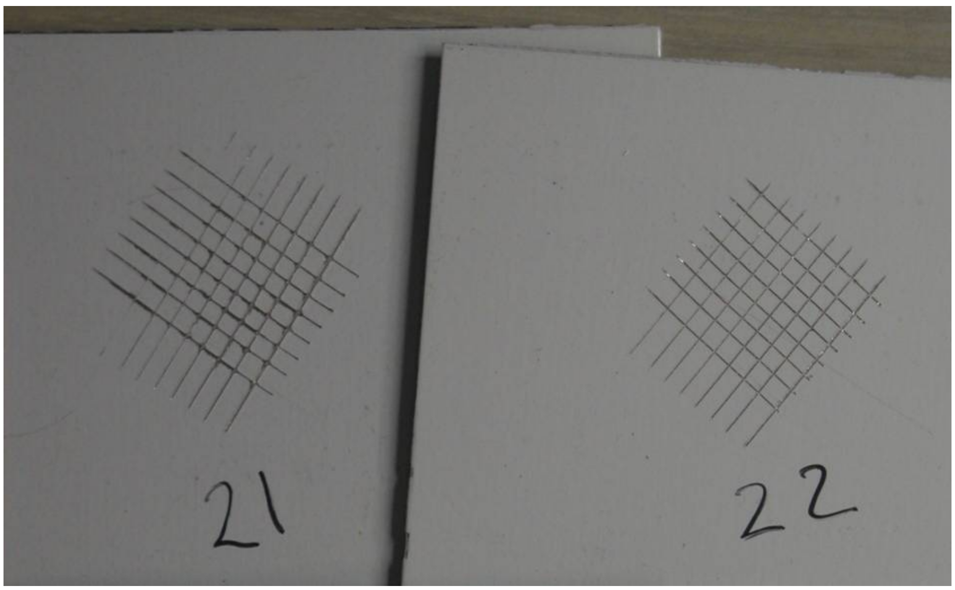


Figure 29. Acceptable Cross-Cut Adhesion Test Outcome

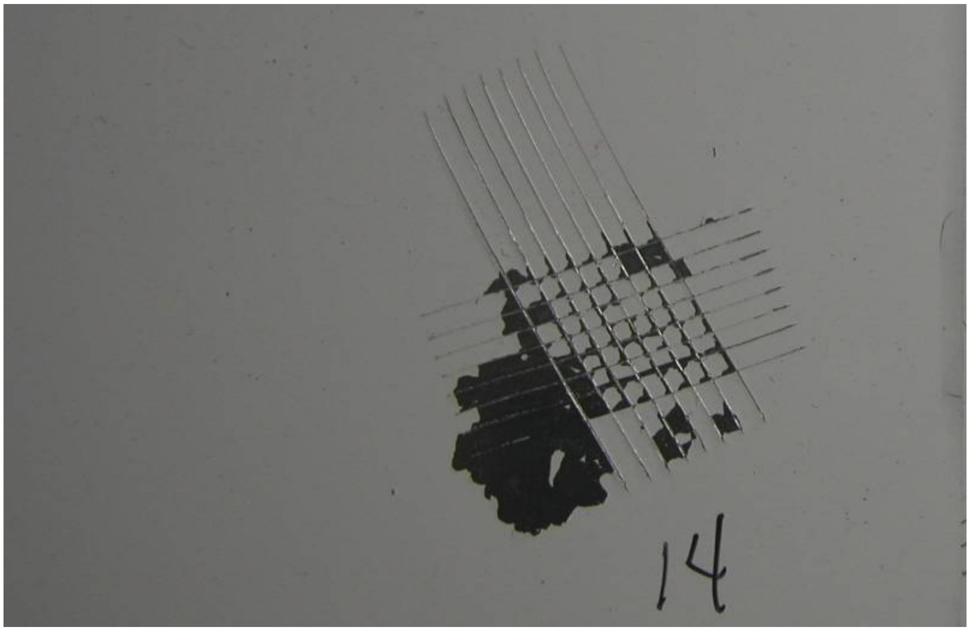


Figure 30. Unacceptable Cross-Cut Adhesion Test Outcome

Cross-cut adhesion test results for LTCPC coupons equaled those of the control coating stack-ups. All but three of the prepared aluminum, steel, and magnesium specimens met the acceptance criteria for intercoat and surface adhesion as defined within the LTCPC JTP. Test results revealed the following unacceptable adhesion ratings: 1B for the untreated, bare 2024-T3 coupon coated with LTCPC; 0B for the untreated 2024-T3 Alclad coupon coated with only a MIL-PRF-85285 topcoat; and 3B for the untreated AZ31B coupon coated with LTCPC. Each of these coupons did not receive surface pretreatment prior to coating application, which likely contributed to their failure as measured by cross-cut adhesion standards. Also, one statistical outlier appears within the reported test results. That failure (2B rating), of an untreated 4130 coupon coated with LTCPC appears to be indicative of a poor surface pretreatment.

6.1.2.7 Impact Flexibility

Impact flexibility was evaluated at Hill AFB using a *Gardner Model 172 Universal Impact Tester* with a GE impacter weighing 3.6 pounds and having semi-spherical indenters protruding out 0.32 to 3.65 millimeters from the surface. The test was performed on 2024 0-Temper aluminum coupons.

An evaluation of test results for impact flexibility indicates acceptable values, i.e., no cracking at indentations generating ≥ 5% elongation of the material.

Table 34. Impact Flexibility Results

Coating System	Substrate	Pretreatment	Coupon 1	Coupon 2	Coupon 3
LTCPC	2024-T0	anodize	5	4	4
MIL-PRF-85285	2024-T0	anodize	2	1	2

= Unacceptable test result
= Marginal test result
= Acceptable test result

Numbers represent indenter Spherical Segment (ref. Table 35) that did not result in cracking of the coating over the deformed substrate

Table 35 (from ASTM D 6905) outlines the relationship between spherical indenters and the percentage of area increase is provided for convenience.

Table 35. Integral Indenter Percent Area Increase

Spherical Segment	End	Base Diameter, mm (in.)	Segment Radius, mm (in.)	Segment Elevation, mm (in.)	%Area Increase
1	A	9.5 (0.375)	4.85 (0.194)	3.65 (0.146)	60
2	A	9.5 (0.375)	5.20 (0.208)	2.98 (0.119)	40
3	A	9.5 (0.375)	6.30 (0.252)	2.10 (0.084)	20
4	A	9.5 (0.375)	8.15 (0.326)	1.48 (0.059)	10
5	B	9.5 (0.375)	11.0 (0.440)	1.05 (0.042)	5
6	B	9.5 (0.375)	16.9 (0.676)	0.68 (0.027)	2
7	B	9.5 (0.375)	23.7 (0.947)	0.48 (0.019)	1
8	B	9.5 (0.375)	33.3 (1.332)	0.32 (0.013)	0.5

Figures 31 and 32 are from impact flexibility testing of the LTCPC and control coupons.

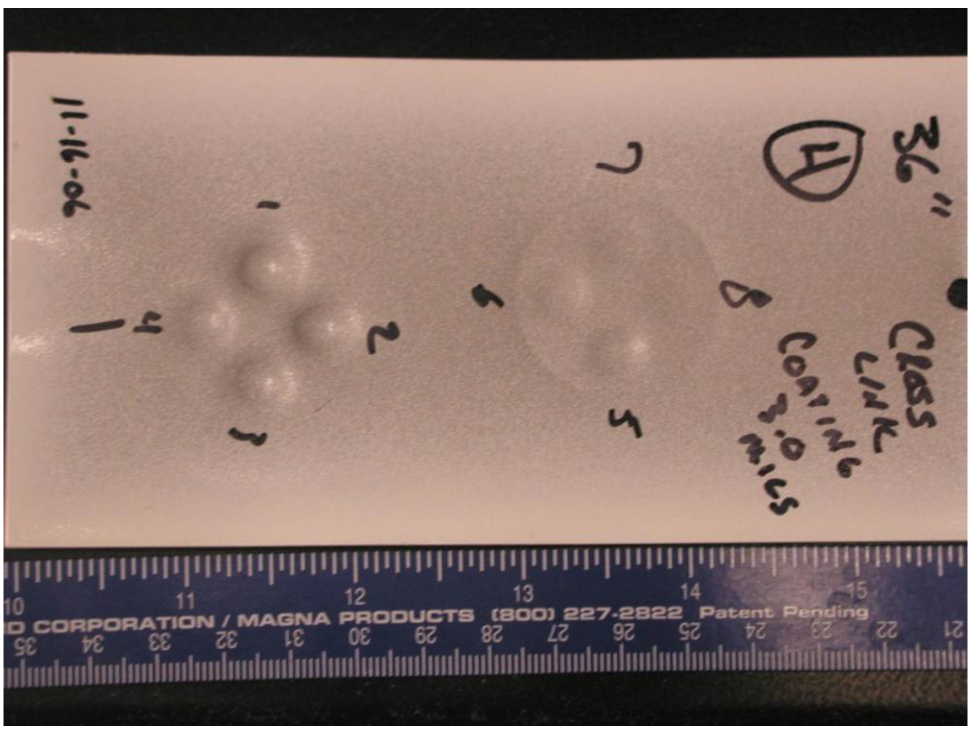


Figure 31. LTCPC Impact Flexibility Test Outcome

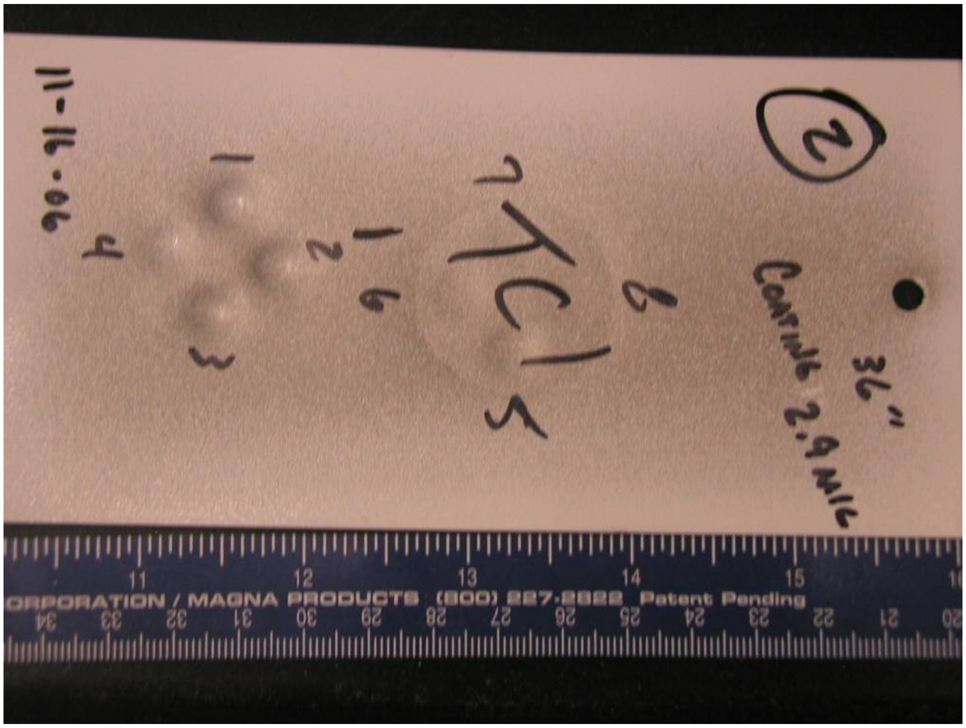


Figure 32. Control Coating Impact Flexibility Test Outcome

Overall impact flexibility test results confirmed that both the LTCPC and control coating coupons met the acceptability criteria of 5% elongation per area increase defined within the Joint Test Protocol. From a comparative standpoint, the control stack-ups demonstrated greater average impact flexibility (47%) as defined by this method than the LTCPC specimens (8%).

6.1.2.8 Strippability

Strippability was evaluated for informational purposes only, as previous research indicated that the LTCPC could be removed with methylene chloride based strippers. The evaluation performed at Hill AFB under the current project looked at a benign benzyl alcohol peroxide stripper and a plastic media blast removal method.

Hill AFB conducted chemical and mechanical strippability studies of the following substrate/coating system combinations.

Table 36. Strippability Study Results

Coating System	Substrate	Pretreatment	Coupon 1
Chemical Stripper (Benzyl alcohol peroxide)			
LTCPC	2024-T3	CCC*	100% after 2 – 4 hours
		none	100% after 2 – 4 hours
	6061-T6	CCC	100% after 2 – 4 hours

Coating System	Substrate	Pretreatment	Coupon 1
		PreKote	100% after 2 – 4 hours
	6060-T6	CCC	100% after 2 – 4 hours
		none	100% after 2 – 4 hours
	2024-T3 Alclad	CCC	100% after 2 – 4 hours
		none	100% after 2 – 4 hours
	4130	Mn phosphate	100% after 2 – 4 hours
		none	100% after 2 – 4 hours
	AZ31B	Dow 7	100% after 2 – 4 hours
		Dow 7 / PreKote	100% after 2 – 4 hours
		none	100% after 2 – 4 hours
MIL-PRF-23377 / MIL-PRF-85285	2024-T3	CCC	100% after 2 – 4 hours
	6061-T6	CCC	100% after 2 – 4 hours
	6060-T6	CCC	100% after 2 – 4 hours
	AZ31B	Dow 7	100% after 2 – 4 hours
MIL-PRF-85285	2024-T3 Alclad	none	100% after 2 – 4 hours
MIL-P-53022 / MIL-PRF-85285	4130	Mn phosphate	100% after 2 – 4 hours
Mechanical Stripper (Type V plastic media)			
LTCPC	2024-T3	CCC	< 3 min
		none	< 3 min
	6061-T6	CCC	< 3 min
		PreKote	< 3 min
	6060-T6	CCC	< 3 min
		none	< 3 min
	2024-T3 Alclad	CCC	< 3 min

Coating System	Substrate	Pretreatment	Coupon 1
		none	< 3 min
	4130	Mn phosphate	< 3 min
		none	< 3 min
	AZ31B	Dow 7	< 3 min
		Dow 7 / PreKote	< 3 min
		none	< 3 min
MIL-PRF-23377 / MIL-PRF-85285	2024-T3	CCC	< 3 min
	6061-T6	CCC	< 3 min
	6060-T6	CCC	< 3 min
	AZ31B	Dow 7	< 3 min
MIL-PRF-85285	2024-T3 Alclad	none	< 3 min
MIL-P-53022 / MIL-PRF-85285	4130	Mn phosphate	< 3 min
Mechanical Stripper (Type VII eStrip GPX media)			
LTCPC	2024-T3	CCC	< 3 min
		none	< 3 min
	6061-T6	CCC	< 3 min
		PreKote	< 3 min
	6060-T6	CCC	< 3 min
		none	< 3 min
	2024-T3 Alclad	CCC	< 3 min
		none	< 3 min
	4130	Mn phosphate	< 3 min
		none	< 3 min
	AZ31B	Dow 7	< 3 min
		Dow 7 / PreKote	< 3 min
		none	< 3 min
MIL-PRF-23377 / MIL-PRF-85285	2024-T3	CCC	< 3 min
	6061-T6	CCC	< 3 min
	6060-T6	CCC	< 3 min
	AZ31B	Dow 7	< 3 min
MIL-PRF-85285	2024-T3 Alclad	none	< 3 min
MIL-P-53022 / MIL-PRF-85285	4130	Mn phosphate	< 3 min

* Chromate Conversion Coating

Figures 33 and 34 are of the test coupons following chemical and mechanical stripping. As can be seen for the chemical stripper test, an amount of the liquid was placed on a coated 12 in. x 12 in. panel. For a successful test, the coating softened and lifted from the substrate (in some cases, light fingertip abrasion could flake off the coating). For the mechanical stripping evaluation, a single three inch strip was media blasted on each panel.

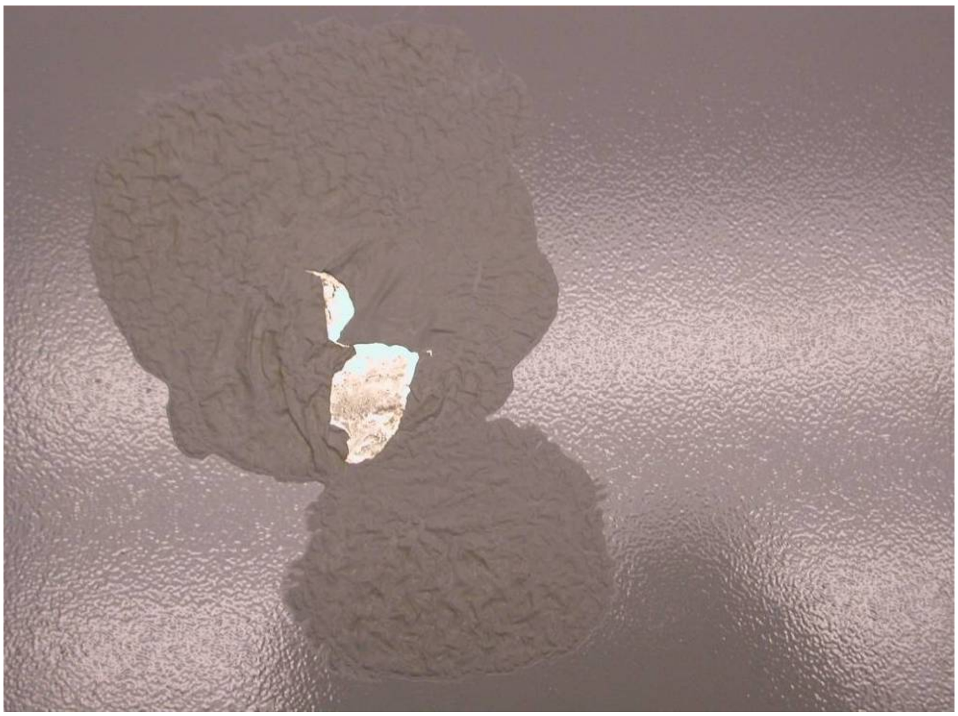


Figure 33. Chemical Strippability Study Outcome

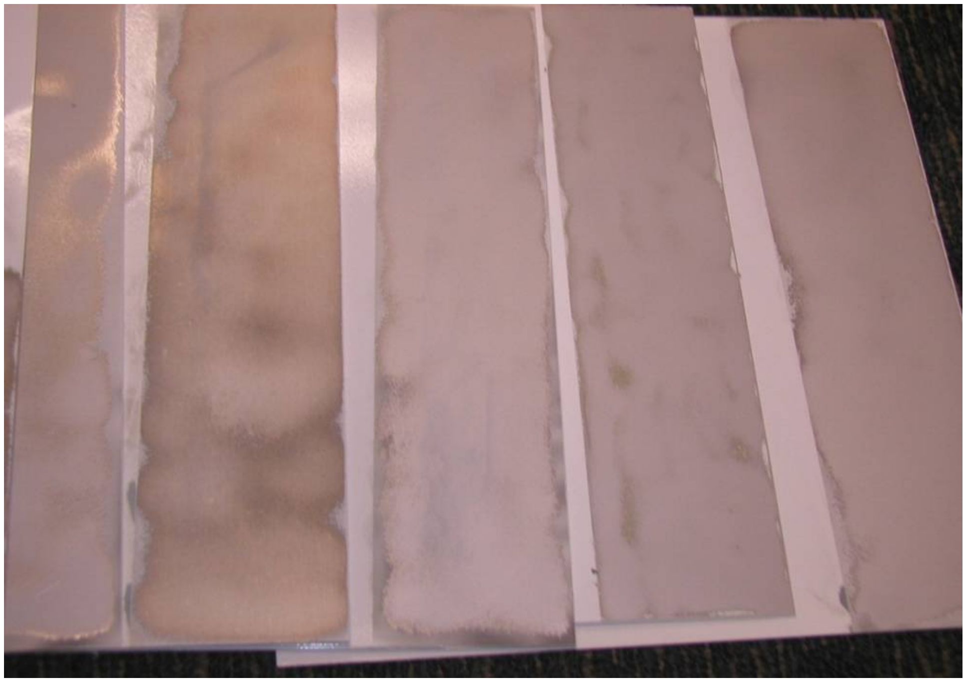


Figure 34. Mechanical Strippability Study Outcome

A comparative study of LTCPC and control coating removal using a non-methylene chloride stripper (benzyl alcohol peroxide) confirmed the product's acceptability. Reported efficiencies for the chemical stripper used on each of the prepared aluminum and steel specimens followed the guidelines provided within the JTP. The benyzl alcohol peroxide's ability to remove 100% of the LTCPC from each substrate met the defined efficiency measures for chemical strippability. With regards to mechanical strippability, Type V plastic and GPX media blasting adequately removed LTCPC from each substrate well within the study's 90 minute time limit.

6.1.3 JTP Addendum

In addition to initial tests determined to be critical to the evaluation of the LTCPC, stakeholders identified several tests as special interest items. NASA stakeholders desired some performance evaluations not critical to other potential LTCPC users. NASA agreed to provide the substrate materials, perform most of the testing and share the results. The specimens were powder coated at Hill AFB concurrently with the JTP coupons.

In addition to the NASA tests, LTCPC team members determined that a few additional performance areas should be quantified. These areas were low temperature flexibility, fluid resistance, and impact/chipping resistance. Low temperature flexibility was performed by the Coatings Technology Integration Office at Wright-Patterson AFB on coupons coated at Hill AFB.

The LTCPC team became aware that fluid resistance and impact/chipping resistance evaluations had been performed under a separate study by the Navy. Rather than duplicate testing, the LTCPC team requested that data; their procedures and results are included in section Appendix E.

6.1.3.1 Neutral Salt Fog Corrosion Resistance on 7075 Aluminum

Three coupons were submitted for salt fog corrosion resistance testing. Of the three, one showed significant blistering of the coating after 1,104 hours of exposure. The other two showed blistering at the completion of the 2,000 hour test. These failures indicate that the LTCPC, as applied in this study, may not be ideal for use on 7075 aluminum components.

Table 37. Neutral Salt Fog Corrosion Resistance on 7075 Al Results

Coating System	Substrate	Pretreatment	Coupon 1	Coupon 2	Coupon 3
LTCPC	7075-T6	none	2000 hrs blistering	2000 hrs blistering	1104 hrs blistering

= Unacceptable test result
= Marginal test result
= Acceptable test result

Figure 35 is the test coupon at the conclusion of the salt fog corrosion resistance testing.

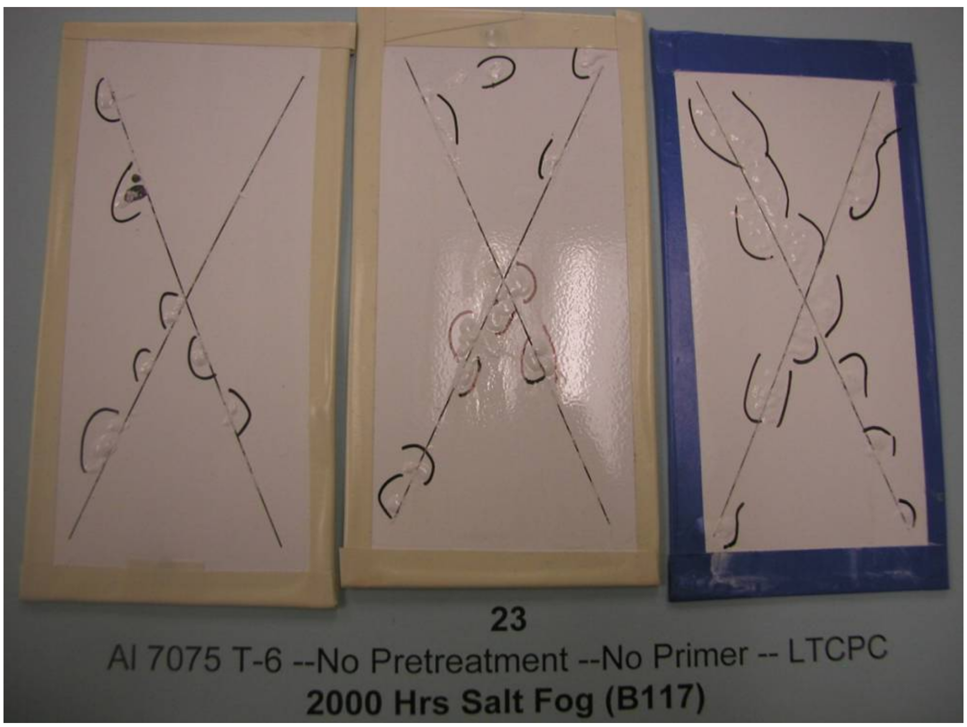


Figure 35. Salt Fog Corrosion Resistance (7075 Al) Test Outcome

6.1.3.2 NASA Extreme Temperature Flexibility

NASA's Kennedy Space Center conducted extreme temperature flexibility testing of the following substrate/coating system combinations. Each coupon failed the extreme low temperature flexibility portion of NASA's testing. Conversely, all three coupons demonstrated acceptable coating flexibility at extremely high temperature.

Table 38. NASA Extreme Temperature Flexibility Results

Coating System	Substrate	Pretreatment	Coupon 1	Coupon 2	Coupon 3	Control
Extreme Low Temperature (–250 °F)						
LTCPC	2024-T3	none	Fail disbonded	Fail disbonded	Fail disbonded	Pass
Extreme High Temperature (+350 °F)						
LTCPC	2024-T3	none	Pass	Pass	Pass	Pass

= Unacceptable test result
= Marginal test result
= Acceptable test result

Figures 36 and 37 are of the test coupons following NASA's extreme temperature flexibility testing.

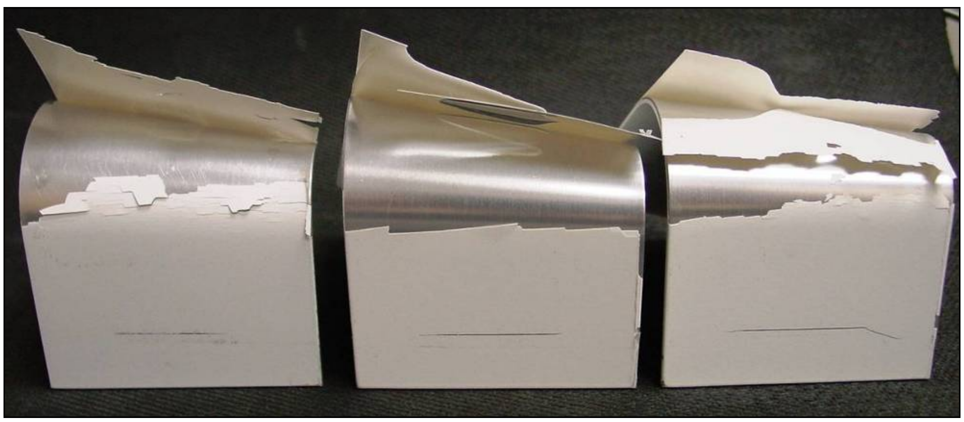


Figure 36. NASA Extreme (–250°F) Temperature Flexibility Test Outcome

Figure 37. NASA Extreme (+350°F) Temperature Flexibility Test Outcome

These tests confirmed stakeholder assumptions that LTCPC would fail to meet flexibility requirements at extremely low temperature due to the coating's overall chemistry. Powder coatings such as LTCPC are comprised of polyester backbones which cure to form thermoset plastics. By design thermoset plastics are more structurally rigid than thermoplastics and therefore suffer from brittleness at extremely low temperatures. NASA's laboratory confirmed this behavior by testing three coupons at minus 250°F, which resulted in disbondment of each LTCPC layer from the 2024-T3 substrates. In contrast to the extreme low temperature results, all three LTCPC coupons successfully passed NASA's testing requirement for extreme high temperature (+350°F) flexibility.

6.1.3.3 NASA Outgassing

NASA's foil specimens for the outgas test proved challenging to properly powder coat due to their small size and weight. Due to the small dimensions and light weight of the foil specimens, difficulties occurred in mounting the coated specimens onto curing racks and then keeping the specimens attached once they were inside the ovens. To address the first issue a bent paper clip was placed through each specimen prior to powder coating. After LTCPC application the paper clips were securely fastened around curing hooks to prevent the specimens from blowing free due to strong oven airflows. At the time of LTCPC application it was not common knowledge that NASA's outgas test required special cleaning and handling of the foil specimens.

The outgas tests were conducted by Boeing at their Huntington Beach, Ca facility, and failed to provide stakeholders with any useful information regarding LTCPC performance. Each of the eight foil samples exceeded the maximum allowable percentages for CVCM and TML as defined within Section 5.1.4.3. The reported CVCM values of 0.30 – 0.76% were well outside the range expected for powder coatings. Calculated values for TML were also unexpectedly high. These test results led stakeholders to review the sample preparation procedures used and identified improper handling as the contributing factor. Boeing's interest in LTCPC (for potential space applications) hinged on the coating's ability to pass both the extreme temperature flexibility and outgassing tests. Therefore Boeing engineers were not interested in preparing a second set of foil specimens once LTCPC failed the extreme low temperature flexibility test.

6.1.3.4 Low Temperature Flexibility

The Air Force's Coatings Technology Integration Office conducted low temperature flexibility testing of the following substrate/coating system combinations. Overall both the LTCPC and control coatings displayed adequate low temperature flexibility as defined within MIL-PRF-85285. Only one coupon failed testing over a one-inch mandrel.

Table 39. Low Temperature Flexibility Results

Coating System	Substrate	Pretreatment	Coupon 1	Coupon 2	Coupon 3	Coupon 4	Coupon 5
LTCPC	2024-T3	none	Fail cracking	Pass	Pass	Pass	Pass
MIL-PRF-23377 / TCI Powder	2024-T3	none	Pass	Pass	Pass	Pass	Pass
MIL-PRF-23377 / 85285	2024-T3	Alodine	Pass	Pass	---	---	---
		PreKote	Pass	Pass	---	---	---

= Unacceptable test result
= Marginal test result
= Acceptable test result

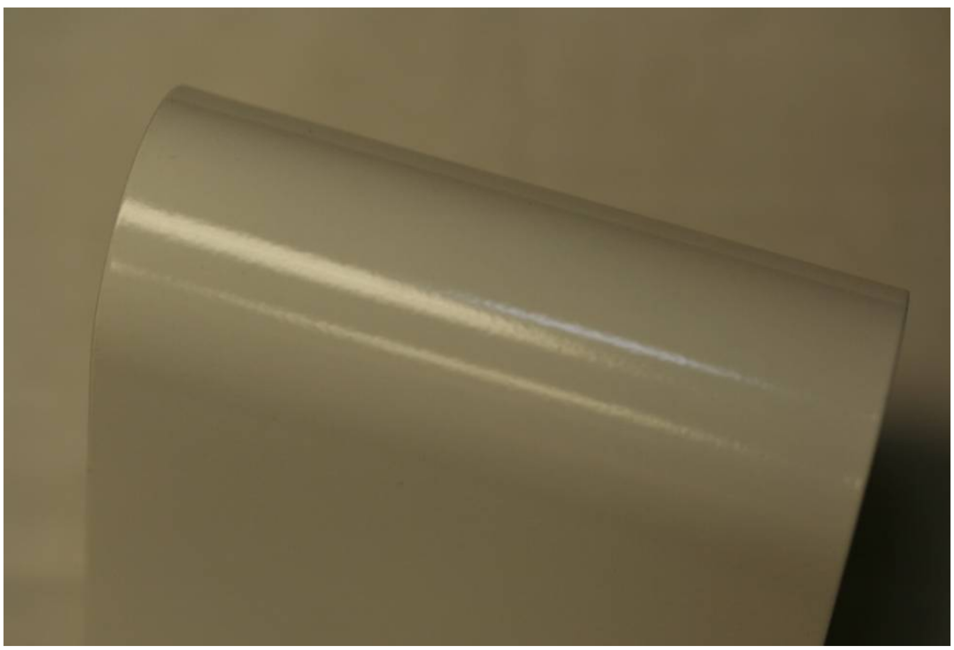


Figure 38. Acceptable LTCPC Low Temperature Flexibility Outcome

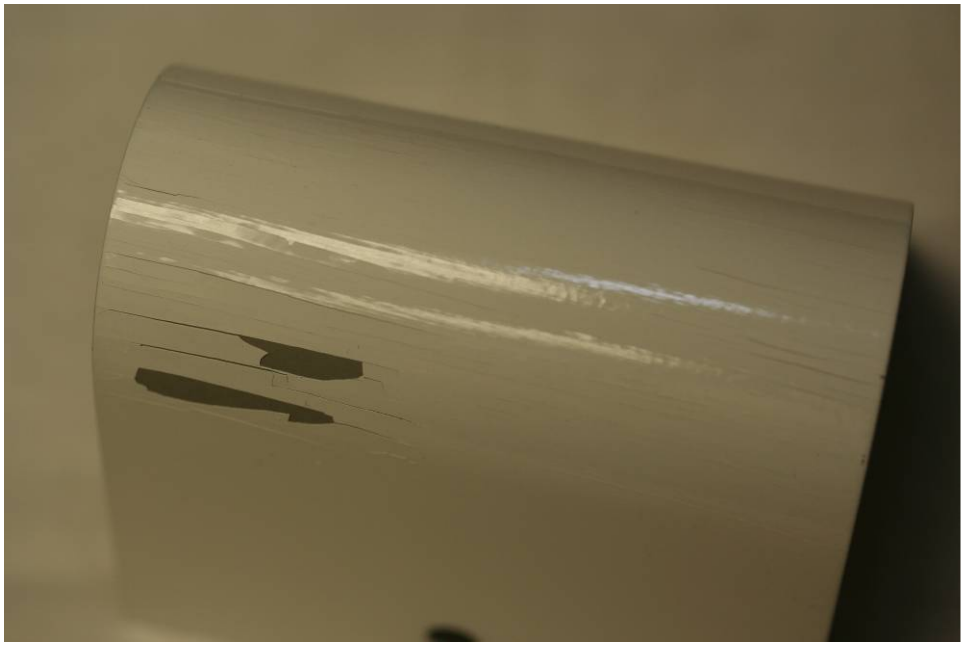


Figure 39. Unacceptable LTCPC Low Temperature Flexibility Outcome

Figure 40. Control Coating Low Temperature Flexibility Outcome

Laboratory test results confirm that LTCPC exhibits acceptable low temperature flexibility as measured by the requirements of MIL-PRF-85285. Each control coupon and all but one of the LTCPC specimens passed low temperature flexibility at -60°F. Stakeholder analysis of the failed test coupon identified adhesion failure due to inconsistent coverage of the chromate pretreatment as the most likely source of cracking within the coating.

6.2 FIELD AND REAL-WORLD TESTING

As discussed in Section 4.1, field service evaluations involved Navy ground support equipment processed at Fleet Readiness Center Northwest and Southwest and Air Force components powder coated at the Ogden Air Logistics Center. The components involved in field service evaluations are listed below (Table 40). The equipment was periodically evaluated for color, gloss, film thickness and general appearance of the coating by the LTCPC project team.

Table 40. FSE Components

Component	Powder Coating Facility	Quantity	Field Service
Nitrogen Servicing Cart	Fleet Readiness Center Southwest	2	Aircraft Carrier Deployment
J52 Aft Engine Yoke	Fleet Readiness Center Northwest	1	Local (NAS Whidbey Island) Airfield Support
C-130 Nose Landing Gear Forward Door	Ogden Air Logistics Center	1	Firefighting Support and Overseas Deployment

6.2.1 Assumptions and Deviations

With regards to color, an assumption has been made to use the CIE 1976 Method for calculating color differences, $\Delta E = ((L_2-L_1)^2 + (a_2-a_1)^2 + (b_2-b_1)^2)^{1/2}$.

A second assumption involves the significance of the various evaluations. It is assumed that one of the most critical factors in acceptance of this technology is end user acknowledgement of superior performance of the coating in durability and protection of the substrate. It was anticipated that conditions in the field might be less than optimum for precise measurement of gloss and color but the LTCPC team considered some amount of unreliability in the measurements to be acceptable if overall adhesive and protective performance of the coating was demonstrated.

As for deviations, during the FSE none of the powder coating facilities prepared control panels during the initial spray-ups to serve as the coating standards required by the project's Demonstration Plan. Therefore, the subsequent color measurements taken after environmental exposure can only be compared against the component's initial measurement.

6.2.2 FSE Measurement and Monitoring

6.2.2.1 Color

The following color measurements were reported by FSE evaluators over the course of each item's 12-month service evaluation. For reference purposes, the following color specification numbers associated with each FSE color number have also been provided.

Table 41. FED-STD-595 Color Specifications

Color Name	Color Number	L	a	b	Illum.
Untinted White	17925	94.270	-0.544	3.625	C
Ocean Gray, NAVSEA	26173	42.895	-0.496	-3.671	C

Table 42. Color Results for Nitrogen Servicing Cart, SN: NRR073

Date		L	a	b
06 March 2008	**Mean (μ)**	**94.21**	**-0.63**	**4.45**
	Standard Deviation (σ)	**0.94**	**0.20**	**0.71**
03 February 2009	**Mean (μ)**	**90.63**	**-0.31**	**6.85**
	Standard Deviation (σ)	**1.55**	**0.22**	**0.95**
04 November 2009	**Mean (μ)**	**87.94**	**0.16**	**9.77**
	Standard Deviation (σ)	**4.28**	**0.22**	**1.99**

FRCSW coated the first nitrogen servicing cart (SN: NRR073) with LTCPC in early March 2008. Initial color measurements taken across the GSE component's surface revealed the average instrument readings of L: 94.21, a: -0.63, and b: 4.45. A ΔE value of 0.83 is obtained when these values are compared against the 17925 color specification located in Table 41. This reveals that the LTCPC initial color is acceptable as defined within the project's Demonstration Plan (ΔE ≤ 1). Subsequent color readings taken in February and November of 2009 resulted in average values of L: 90.63, a: -0.31, b: 6.85 and L: 87.94, a: 0.16, b: 9.77, respectively. ΔE values of 4.3 and 8.3 result from the comparison of these second and third values against the initial component readings. While these ΔE values are large, it is difficult to determine the significance of the changes in the absence of a control, which would eliminate the possibility of changes due to instrument drift.

Table 43. Color Results for Nitrogen Servicing Cart, SN: NRR204

Date		L	a	b
06 March 2008	**Mean (μ)**	**94.19**	**-0.55**	**3.72**
	Standard Deviation (σ)	**0.97**	**0.31**	**0.51**
03 February 2009	**Mean (μ)**	**90.24**	**-0.36**	**7.56**
	Standard Deviation (σ)	**2.54**	**0.28**	**1.84**

FRCSW also coated the second nitrogen servicing cart (SN: NRR204) with LTCPC in early March 2008. Initial color measurements taken across the GSE component's surface revealed the average instrument readings of L: 94.19, a: -0.55, and b: 3.72. A ΔE value of 0.12 is obtained when these values are compared against the 17925 color specification. This reveals that the LTCPC initial color is acceptable as defined within the project's Demonstration Plan (ΔE ≤ 1). Subsequent color readings taken in February 2009 resulted in average values of L: 90.24, a: -0.36, and b: 7.56. A ΔE value of 5.5 results from the comparison of these second values against the initial component readings. As with the first nitrogen cart, while this ΔE value is large it is difficult to determine the significance of the change in the absence of a control panel.

It should be noted that stakeholders attempted to take color readings for the second cart in November 2009. However, an undetermined color instrument failure resulted in no reportable measurements for that inspection.

Table 44. Color Results for J52 Aft Engine Yoke, SN: P9H513

Date		L	a	b
30 January 2008	**Mean (μ)**	**92.14**	**-1.06**	**4.02**
	Standard Deviation (σ)	**2.70**	**0.14**	**0.86**
17 July 2008	**Mean (μ)**	**91.95**	**-0.65**	**2.72**
	Standard Deviation (σ)	**1.49**	**0.16**	**0.59**
27 January 2009	**Mean (μ)**	**93.04**	**-0.62**	**2.83**
	Standard Deviation (σ)	**1.57**	**0.14**	**0.64**

FRCNW coated the J52 aft engine yoke (SN: P9H513) with LTCPC in late January 2008. Initial color measurements taken across the GSE component's surface revealed the average instrument readings of L: 92.14, a: -1.06, and b: 4.02. A ΔE value of 2.2 is obtained when these values are compared against the 17925 color specification. This reveals that the LTCPC initial color for this component is unacceptable as defined within the project's Demonstration Plan (ΔE ≤ 1). The standard deviation associated with the reported L values is 2.70, suggesting that measurements taken on the curved surfaces of the engine yoke (ref. illustration within Table 84, Appendix F) were most likely affected by environmental light pollution. Subsequent color readings taken in July 2008 and January 2009 resulted in average values of L: 91.95, a: -0.65, b: 2.72, and L: 93.04, a: -0.62, b: 2.83, respectively. ΔE values of 1.4 and 1.6 result from the comparison of these second and third values against the initial component readings. While these values are slightly larger than the maximum allowable ΔE shift, it is difficult to determine the significance of the change in the absence of a control panel.

Table 45. Color Results for C-130 Nose Landing Gear Forward Door, AC: 92-1534

Date		L	a	b
May 2008	**Mean (μ)**	**66.08**	**-4.84**	**1.43**
	Standard Deviation* (σ)	**0.11**	**0.07**	**0.05**
July 2009	**Mean (μ)**	**66.20**	**-4.96**	**1.11**
	Standard Deviation* (σ)	**0.13**	**0.02**	**0.06**

* Calculations are questionable due to very small sample size

OO-ALC coated the C-130 Nose Landing Gear Forward Door (AC: 92-1534) with LTCPC in May 2008. Initial color measurements taken across the aircraft component's surface revealed the average instrument readings of L: 66.08, a: -4.84, and b: 1.43. A ΔE value of 24.1 is obtained when these values are compared against the 26173 color specification. This reveals that the LTCPC initial color is unacceptable as defined within the project's Demonstration Plan (ΔE ≤ 1). Subsequent color readings taken in July 2009 resulted in average values of L: 66.20, a: -4.96, and b: 1.11. A ΔE value of 0.36 results from the comparison of these second values against the initial component readings. While this ΔE value is less than one it is difficult to determine the significance of the change in the absence of a control panel.

Table 46. Color Results for C-130 Nose Landing Gear Aft Door, AC: 92-1534

Date		L	a	b
May 2008	**Mean (μ)**	**66.12**	**-4.82**	**1.48**
	Standard Deviation* (σ)	**0.05**	**0.05**	**0.24**
July 2009	**Mean (μ)**	**66.14**	**-4.74**	**1.06**
	Standard Deviation* (σ)	**0.16**	**0.06**	**0.06**

* Calculations are questionable due to very small sample size

OO-ALC also coated the C-130 Nose Landing Gear Aft Door (AC: 92-1534) with LTCPC in May 2008. Initial color measurements taken across the aircraft component's surface revealed the average instrument readings of L: 66.12, a: -4.82, and b: 1.48. A ΔE value of 24.2 is obtained when these values are compared against the 26173 color specification. This reveals that the LTCPC initial color is unacceptable as defined within the project's Demonstration Plan (ΔE ≤ 1). Subsequent color readings taken in July 2009 resulted in average values of L: 66.14, a: -4.74, and b: 1.06. A ΔE value of 0.43 results from the comparison of these second values against the initial component readings. While this ΔE value is less than one it is difficult to determine the significance of the change in the absence of a control panel.

6.2.2.2 Gloss

Gloss measurements were taken for each FSE component over the course of the item's 12-month service evaluation.

Table 47. Gloss Results for Nitrogen Servicing Cart, SN: NRR073

	Angle	06 Mar 2008	03 Feb 2009	04 Nov 2009
Mean (μ)	60°	67.28	58.75	38.42
	85°	75.58	72.70	59.97
Standard Deviation (σ)	60°	9.73	12.10	14.88
	85°	11.88	13.60	18.64

The initial gloss measurements taken at FRCSW across the first nitrogen servicing cart's surface in early March 2008 revealed the average instrument reading of 67.28 gloss units at a 60° angle of incidence. This value reveals that the LTCPC initial specular gloss is not as high as called out in the project's Demonstration Plan (≥ 90 for gloss finishes). Subsequent gloss readings taken in February and November of 2009 resulted in average gloss values of 58.75 and 38.42, respectively. The reduction in average gloss units documented from the initial through third inspections suggests that LTCPC gloss has been partially diminished by 20 months of environmental exposure. However, project stakeholders have confirmed that LTCPC gloss retention is as good as or better than the baseline wet topcoat.

Table 48. Gloss Results for Nitrogen Servicing Cart, SN: NRR204

	Angle	06 Mar 2008	03 Feb 2009	04 Nov 2009
Mean (μ)	60°	65.23	58.62	51.11
	85°	77.29	73.38	79.48
Standard Deviation (σ)	60°	7.06	15.61	11.81
	85°	8.72	16.18	8.25

Similarly, initial gloss measurements taken at FRCSW across the second nitrogen servicing cart's surface in early March 2008 revealed an average instrument reading of 65.23 gloss units at a 60° angle of incidence. This value reveals that the LTCPC initial specular gloss is not as high as called out in the project's Demonstration Plan (≥ 90 for gloss finishes). Subsequent gloss readings taken in February and November of 2009 resulted in average gloss values of 58.62 and 51.11, respectively. This reduction in average gloss units documented from the initial through third inspections suggests that LTCPC gloss has been partially diminished by 20 months of environmental exposure. However, project stakeholders have confirmed that LTCPC gloss retention is as good as or better than the baseline wet topcoat.

Table 49. Gloss Results for J52 Aft Engine Yoke, SN: P9H513

	Angle	30 Jan 2008	17 Jul 2008	27 Jan 2009
Mean (μ)	60°	33.60	22.30	38.71
	85°	34.38	34.23	58.30
Standard Deviation (σ)	60°	8.37	4.10	13.14
	85°	9.93	5.33	13.63

The initial gloss measurements taken at FRCNW across the aft engine yoke's surface in late January 2008 revealed an average instrument reading of 33.60 gloss units at a 60° angle of incidence. This value reveals that the LTCPC initial specular gloss is not as high as called out in the project's Demonstration Plan (≥ 90 for gloss finishes). The standard deviation associated with the reported gloss readings is 8.37, suggesting that measurements taken on the curved surfaces of the engine yoke (ref. illustration within Table 84, Appendix F) were most likely affected by curvature effects. Subsequent gloss readings taken in July 2008 and January 2009 resulted in average gloss values of 22.30 and 38.71, respectively. The observed fluctuations (both directions) in average gloss units documented from the initial through third inspections suggest that a level of inaccuracy exists within some or all of the LTCPC gloss readings. However, project stakeholders have received feedback from field users attesting to the acceptability of the component's surface appearance.

Table 50. Gloss Results for C-130 Nose Landing Gear Forward Door, AC: 92-1534

	Angle	May 2008	July 2009
Mean (μ)	60°	35.18	36.29
	85°	21.59	25.57
Standard Deviation (σ)	60°	8.21	3.50
	85°	5.70	3.87

The initial gloss measurements taken at OO-ALC across the interior of the C-130 nose landing gear's forward door surface in May 2008 revealed an average value of 35.18 gloss units at a 60° angle of incidence. This average reveals that the LTCPC initial specular gloss is acceptable as defined within the project's Demonstration Plan ($30 \leq x \leq 45$ for semi-gloss finishes). Subsequent LTCPC gloss readings taken in July 2009 resulted in an average gloss value of 36.29, which is also within the acceptable range.

Table 51. Gloss Results for C-130 Nose Landing Gear Aft Door, AC: 92-1534

	Angle	May 2008	July 2009
Mean (μ)	60°	42.68	43.50
	85°	32.98	32.78
Standard Deviation* (σ)	60°	6.59	7.85
	85°	4.52	5.78

* Calculations are questionable due to small sample size

Likewise, initial gloss measurements taken at OO-ALC across the interior of the C-130 nose landing gear's aft door surface in May 2008 revealed an average value of 42.68 gloss units at a 60° angle of incidence. This average reveals that the LTCPC initial specular gloss is acceptable as defined within the project's Demonstration Plan ($30 \leq x \leq 45$ for semi-gloss finishes). Subsequent LTCPC gloss readings taken in July 2009 resulted in an average gloss value of 43.50, which is also within the acceptable range.

6.2.2.3 Film Thickness

The dry film thickness measurements taken during the course of the component's 12-month field service evaluation are provided below.

Table 52. Dry Film Thickness Results for Nitrogen Servicing Cart, SN: NRR073

	06 Mar 2008 (mils)	03 Feb 2009 (mils)	04 Nov 2009 (mils)
Mean (μ)	7.76	7.45	8.70
Standard Deviation (σ)	3.53	3.88	3.43

The initial dry film thickness measurements taken at FRCSW across the first nitrogen servicing cart's surface in early March 2008 revealed the average coating thickness to be 7.76 mils. This relatively large value reveals the use of the project's previously documented two-pass LTCPC application method. Subsequent thickness readings taken in February and November of 2009 resulted in average film thicknesses of 7.45 and 8.70 mils, respectively. The reported decrease then subsequent increase in average dry film thickness documented from the initial through third inspections suggests that a level of difficulty exists with taking measurements from the same component locations over time. However, project stakeholders have confirmed that LTCPC film thickness over the cart's FSE period remained within the range of acceptability.

Table 53. Dry Film Thickness Results for Nitrogen Servicing Cart, SN: NRR204

	06 Mar 2008 (mils)	03 Feb 2009 (mils)	04 Nov 2009 (mils)
Mean (μ)	7.62	7.22	7.13
Standard Deviation (σ)	1.92	1.51	1.82

Similarly, the initial dry film thickness measurements taken at FRCSW across the second nitrogen servicing cart's surface in early March 2008 revealed the average coating thickness to be 7.62 mils. This relatively large value reveals the use of the project's previously documented two-pass LTCPC application method. Subsequent thickness readings taken in February and November of 2009 resulted in average film thicknesses of 7.22 and 7.13 mils, respectively. The high uncertainty (large standard deviation) in average dry film thickness documented in each of the inspections suggests that a level of inaccuracy exists within some or all of the LTCPC thickness readings. However, project stakeholders have confirmed that LTCPC film thickness over the cart's FSE period remained within the range of acceptability.

Table 54. Dry Film Thickness Results for J52 Aft Engine Yoke, SN: P9H513

	30 Jan 2008 (mils)	17 Jul 2008 (mils)	27 Jan 2009 (mils)
Mean (μ)	3.04	3.84	3.88
Standard Deviation (σ)	0.78	1.22	1.53

Initial dry film thickness measurements taken at FRCNW across the J52 aft engine yoke's surface in late January 2008 revealed an average coating thickness of 3.04 mils. The wide range of observed readings associated with this average thickness is indicative of the project's previously documented two-pass LTCPC application method. Subsequent thickness readings taken in July 2008 and January 2009 produced average film thicknesses of 3.84 and 3.88 mils, respectively. The fluctuations in average dry film thickness documented from the initial through third inspections suggest that a level of inaccuracy exists within some or all of the LTCPC thickness readings. However, project stakeholders have confirmed that LTCPC film thickness over the yoke's FSE period remained within the range of acceptability.

Table 55. Dry Film Thickness Results for C-130 Nose Landing Gear Forward Door, AC: 92-1534

	May 2008 (mils)	July 2009 (mils)
Mean (μ)	3.08	3.03
Standard Deviation (σ)	0.43	0.40

The initial dry film thickness measurements taken at OO-ALC across the interior surface of the C-130 nose landing gear's forward door in May 2008 revealed an average coating thickness of 3.08 mils. This average thickness is indicative of the project's previously documented single-pass LTCPC application method. Subsequent thickness readings taken in July 2009 resulted in an average film thickness of 3.03 mils. The slight reduction in average dry film thickness documented from the initial to second inspections suggests that LTCPC has experienced partial shrinkage over the 12 months of environmental exposure. However, project stakeholders have confirmed that LTCPC film thickness over the forward door's FSE period remained within the range of acceptability.

Table 56. Dry Film Thickness Results for C-130 Nose Landing Gear Aft Door, AC: 92-1534

	May 2008 (mils)	July 2009 (mils)
Mean (μ)	2.07	2.38
Standard Deviation (σ)	0.31	0.38

In comparison, initial dry film thickness measurements taken at OO-ALC across the interior surface of the C-130 nose landing gear's aft door in May 2008 revealed an average coating thickness of 2.07 mils. This average thickness is indicative of the project's previously documented single-pass LTCPC application method. Subsequent thickness readings taken in July 2009 resulted in an average film thickness of 2.38 mils. The fluctuation in average dry film thickness documented between the initial and second inspections suggest that a level of inaccuracy exists within some or all of the LTCPC thickness readings. However, project stakeholders have confirmed that LTCPC film thickness over the aft door's FSE period remained within the range of acceptability.

6.2.2.4 Surface Appearance

Stakeholders evaluated the surface appearance of the LTCPC with unaided eyes for visible coating or surface defects. There were no noteworthy surface appearance deficiencies reported during the course of each component's FSE period, outside of the normal level of wear and tear.

6.2.3 Completed FSE Component Photographs

6.2.3.1 Nitrogen Servicing Cart (USN)

The following photographs were taken prior to deployment and over the course of the FSE aboard USN aircraft carriers.

Figure 41. Nitrogen Servicing Cart (SN: NRR073) Prior to Carrier Exposure

Figure 42. Nitrogen Servicing Cart (SN: NRR073) After 6 Months of Carrier Exposure

Figure 43. Nitrogen Servicing Cart (SN: NRR073) After 18 Months of Carrier Exposure

Figure 44. Nitrogen Servicing Cart (SN: NRR204) Prior to Carrier Exposure

Figure 45. Nitrogen Servicing Cart (SN: NRR204) After 6 Months of Carrier Exposure

Figure 46. Nitrogen Servicing Cart (SN: NRR204) After 18 Months of Carrier Exposure

6.2.3.2 J52 Aft Engine Yoke (USN)

The following photographs were taken prior to use during the FSE deployment at FRCNW.

Figure 47. J52 Aft Engine Yoke (SN: P9H513) Prior to Coastal Exposure

Figure 48. J52 Aft Engine Yoke (SN: P9H513) Prior to Coastal Exposure

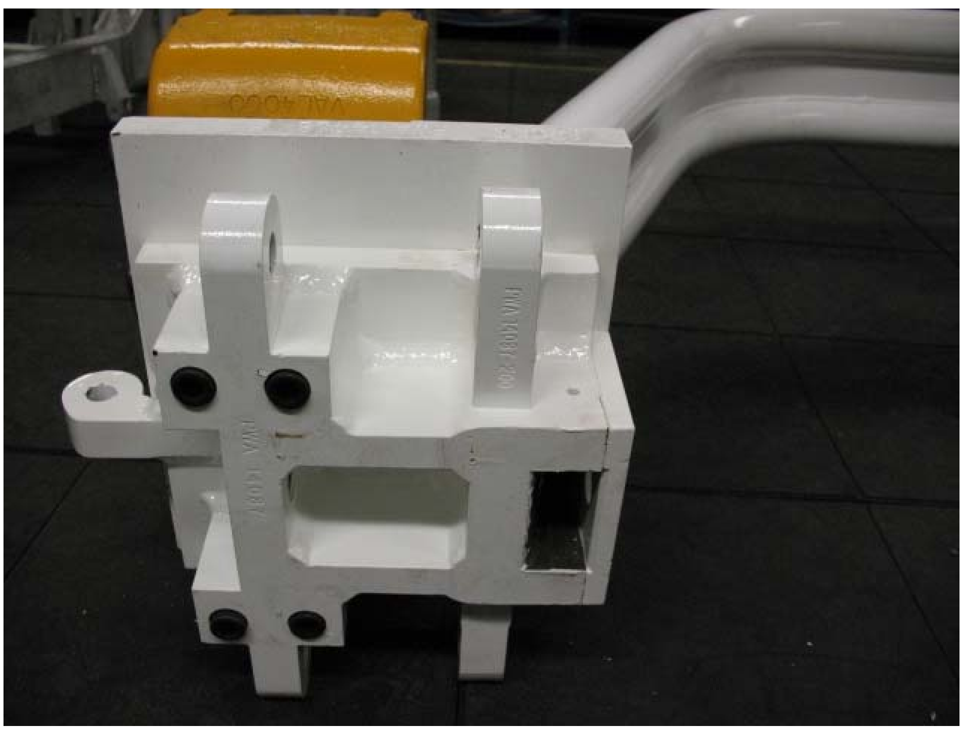


Figure 49. J52 Aft Engine Yoke (SN: P9H513) Support Prior to Coastal Exposure

6.2.3.3 C-130 Nose Landing Gear Forward and Aft Doors (USAF)

The following photographs were taken during the course of the FSE deployment to various theaters of operation.

Figure 50. C-130 Nose Landing Gear Forward Door (AC: 92-1534) After 12 Months of Exposure

Figure 51. C-130 Nose Landing Gear Aft Door (AC: 92-1534) After 12 Months of Exposure

Figure 52. C-130 Nose Landing Gear Aft Door (AC: 92-1534) After 12 Months of Exposure

7.0 COST ASSESSMENT

7.1 COST MODEL

7.1.1 Description

LTCPC stakeholders consistently utilized the Environmental Cost Analysis Methodology (ECAM)^{SM} approach to determine both the direct process costs as well as the costs associated with indirect environmental activities for both the baseline and LTCPC processes. The National Defense Center for Energy and the Environment (NDCEE) developed the ECAM methodology at the request of the Office of the Deputy Under Secretary of Defense for Environmental Security, to provide Department of Defense (DoD) project managers with a consistent approach to quantifying and evaluating environmental costs and benefits. The ECAM Level I strives to identify the direct costs (conventional and environmental) associated with both the baseline and proposed technologies, while an ECAM Level II seeks to establish the costs of additional environmental activities supporting the process under consideration, which are usually performed for the entire facility.[8]

When utilizing a methodology such as ECAM, it is critical that key pieces of data be identified and quantified with the greatest level of accuracy possible. This process encompasses identifying the resources consumed by each environmental activity as well as the associated unit costs.

Within the context of environmental activities, resources are the goods and services consumed during the process of achieving the desired end state. These resources may include both in-house and contract labor, contractor services, and process materials. Once the relevant resources are determined, the drivers for each activity are then identified. These drivers, or distinct units of measurement associated with the activity, reveal the relationship between a resource and the cost of shared (i.e. facility-wide) environmental activities. This in turn allows investigators to provide approximations for the driver's "per unit" costs. Typically these drivers are dependant upon a user community's accepted unit of measurement such as the number of waste streams, number of affected employees, item weight, or item volume.

7.1.2 Data Requirements

For the initial Level I analysis, facility personnel provided the NDCEE with estimates of the direct costs during the development of the ESTCP project proposal. Where necessary, NDCEE later verified the cost data through phone interviews with project stakeholders. The Level I analysis focused on:

- Equipment Purchases
- Process Consumables
- Utilities
- Process Labor
- Personal Protection Equipment
- Waste Streams

A copy of the Level I CBA report, entitled "Final Type A Cost Benefit Analysis of Low Temperature Cure Powder Coating", can be obtained from Mr. Andy Del Collo, Office of the Chief of Naval Operations, Environmental Readiness Division, in Arlington, VA.

For the Level II analysis, project stakeholders accomplished data collection related to environmental activities by means of a comprehensive questionnaire that took into consideration the resources and drivers associated with each activity. This questionnaire was built from a list of suggested questions provided within Appendix B-4 of the ECAM Handbook and expanded upon, when necessary, in order to capture all potential environmental activities costs. The primary areas of focus for the questionnaire included:

- Operating and Maintaining Equipment and Facilities
- Providing and Administering Training
- Obtaining and Maintaining Permits
- Supporting Facility Operations
- Developing and Maintaining Documentation

A copy of the baseline and LTCPC questionnaire resides within Appendix B of the LTCPC ECAM Level II CBA report, entitled "Cost Benefit Analysis of Indirect Environmental Activities for Validation of Low Temperature Cure Powder Coating, WP-0614".

7.1.3 Performing Organization

LTCPC stakeholders directed individuals from NDCEE to provide assistance in gathering process data related to the ECAM Level I CBA, which estimated the start-up and direct process costs associated with transitioning from a wet paint process to LTCPC.

ECAM methodology was also used when SAIC performed the subsequent Level II analysis to examine LTCPC's impact on indirect environmental activity costs.

7.1.4 Assumptions

For the Level I ECAM, the following list of assumptions was utilized in order to estimate the direct process costs associated with both the baseline and LTCPC processes.

- Recurring equipment costs for baseline process were estimated
- Rework will remain constant
- The number of parts to be painted (surface area) for each facility will remain constant for the time period of this analysis
- Based on data gathered at several of the facilities, a primer thickness of 1 mil and two topcoats of 2 mil each are assumed to be the baseline at each facility
- For the low temperature cure powder coating, it is assumed no primer is needed
- A ratio of solvent (used for equipment cleaning, surface preparation, and viscosity reduction) to total coating was estimated
- No major equipment will need to be replaced for any paint application method within the time frame of this CBA

- All surveyed facilities are in compliance with all affected regulatory permits; so transitioning to the alternatives will not eliminate fines
- Purchase of an electric heat driven curing oven
- Labor and material requirements are derived from a surface area estimate of 1,476 square feet per year with a component tempo of 308 parts per year (based upon the original list of components identified by LTCPC stakeholders at the beginning of this project)
- Curing oven electricity use constitutes no less than 50% of the usage total calculated for the LTCPC process

Likewise for the Level II ECAM, stakeholders utilized educated assumptions in defining the processes, and when the necessary environmental activity metrics were unavailable or undeterminable within the timeframe required by this CBA Report. These assumptions include:

- Surface preparation of substrates is identical for both processes
- Primer is only applied to the substrate when using wet paint (i.e., no primer is applied under the LTCPC)
- Five painters are required for the baseline wet paint or powder coating shop
- The Personal Protection Equipment (PPE) item "Heavy duty blast suit" is replaced twice per year
- Two contractors are utilized for Operations and Maintenance (O&M) of environmental equipment and facilities
- 60 man-hours are shared between the four military members assigned to O&M of environmental equipment and facilities
- 30 man-hours are shared between the two contractors utilized for O&M of environmental equipment and facilities
- The current contractor charges a fully burdened rate of $100 per hour for O&M of environmental equipment and facilities
- One GS-11 level civilian is assigned wet paint school instructor duties
- One contractor is responsible for one-day powder coating instructor duties
- The current contractor charges a fully burdened rate of $100 per hour for powder coating instructor duties
- The average Navy painter possesses an enlisted rank of E-3
- Five painters complete annual refresher training
- The annual refresher training is an self-paced course that requires no instructor to complete
- One GS-9 level civilian is responsible for in-house training material (courseware) development

- 40 man-hours are allocated to the development of Standard Operating Procedures (SOP) training materials
- A team of three GS-9 level and 2 GS-11 level civilians comprise the internal audit team
- One GS-9 or GS-11 level civilian is required to generate internal audit checklists and documentation
    - Pay bands for GS-9 and GS-11 level civilians will be averaged to utilize a midrange value where only one civilian is assigned to a particular task
- One GS-9 or GS-11 level civilian is accountable for completing internal audit reports
    - Pay bands for GS-9 and GS-11 level civilians will be averaged to utilize a midrange value where only one civilian is assigned to a particular task
- The overall time requirement to complete activities related to on-site hazardous material handling, transportation, and storage of wet painting waste is divided equally between each of the five individuals
- A team of 10 civilians (five GS-9 level, three GS-11 level, and two GS-12 level) is required to complete various activities comprising the development and maintenance of facility documentation
- The overall time requirement to complete activities comprising the development and maintenance of facility documentation is divided equally between each of the 10 individuals
- Overall time requirements for the following facility document development and maintenance activities are:
    - Create and maintain MSDS forms - 8 hrs
    - Prepare spill/release emergency plans - 12 hrs
    - Prepare accident plans - 12 hrs
    - Perform internal industrial hygiene survey/report - 40 hrs
    - Oversee industrial hygiene audit by external agency - 24 hrs
    - Develop employee duties/responsibilities/procedures - 12 hrs
    - Prepare TRI reports - 40 hrs
    - Prepare EPCRA reports - 40 hrs
    - Prepare state reports - 40 hrs
    - Develop and maintain programs and procedures - 12 hrs
    - Develop and maintain strategic plans and budgets - 24 hrs
    - Prepare container labels - 8 hrs
    - Fill manifest forms - 8 hrs
    - Prepare supply orders - 12 hrs

- The current contractor charges a fully burdened rate of $100 per hour for the execution of annual physicals and PPE fit-testing
- The costs associated with annual physicals and fit-testing will be the same for FRCNW and OO-ALC
- A composite locality payment rate, based upon the average of rates assigned to NAS Whidbey Island, NAS North Island, Hill AFB, and Warner-Robins AFB, will be used when estimating mean annual salaries for civilian employees
- The powder coating facility will operate 250 days per year

The following assumptions were used during the calculation of financial metrics associated with the life cycle costs of LTCPC.

- LTCPC start-up activities are completed by the start of Q4, FY2011 (3 months to obligate funds; 6 months to install)
- Three USAF Depots will implement LTCPC (Ogden, Oklahoma City, and Warner-Robins ALCs)
- Four USN facilities will implement LTCPC (FRCNW Whidbey Island, FRCSW North Island, FRCSE Jacksonville, and FRCE Cherry Point)

7.1.4.1 Transfer Efficiencies

For the purposes of calculating cost savings, LTCPC was assigned a projected transfer efficiency of 95% (typical of powder coatings) compared to the 70% transfer efficiency associated with traditional liquid spray painting.

7.1.4.2 Emissions Monitoring and Reporting

The burden of emissions monitoring and reporting will be expressed as a percentage of each facility's total compliance costs based upon the number of waste streams contributing to the environmental burden.

7.1.4.3 Scale of Operations

The scale of operations for identified components exhibit a wide range of values. Estimates for component depot throughputs are provided within Table 57. Overall, the components selected for this effort demonstrated and validated LTCPC for a wide range of temperature sensitive components.

Table 57. Expected Scale of Operations for Targeted LTCPC Components

LTCPC Component	Component Coated Surface Area (in^2)	Estimated Depot Tempo (items/yr)	Total LTCPC Surface Area (ft^2)
F-15 A/C Mounted Accessory Drive	1,321	476	4,367
F-16 Accessory Drive Gearbox	690	308	1,476
TF33 Engine 2nd Stage Stator	2,000	24	333
Aero 12C Bomb Cart	2,275	100	1,580
NAN-4 Cart	8,496	20	1,180
Adjustable Length Tow Bar	7,675	15	800
EA-6B Jammer Pod Rails	1,757	80	976
EA-6B Jammer Pod Cradle	2,232	80	1,240
C-130 Landing Gear Doors	*	*	*
J52 Aft Engine Yoke	2,348	13	212
J52 Forward Engine Yoke	5,482	15	571
Engine Support Adapter	294	4	8
HLU-288 Bomb Hoist	2275	2	32

*information unavailable

7.1.4.4 Life Cycle Costs Time Frame

Unless otherwise noted, all Life Cycle Costs (LCC) calculations are based upon an assumed operations and maintenance lifespan of 10 or 20 years. The appropriate reapplication period for LTCPC consideration is defined by the time elapsing between scheduled depot maintenance cycles for demonstration articles. For both the non-critical flight components and ground support equipment involved in this project a typical depot cycle is approximately two years.

7.1.5 Cost Revisions

Changes made to the initial Level I cost estimates are documented below along with the justification for each revision.

- Man-hour estimates for the application of wet primer and topcoat onto components
    - Reason: An extensive application time study was completed in order to more precisely determine the man-hour requirement for a representative component using the baseline process
- Man-hour estimates for the application of LTCPC onto components
    - Reason: An extensive application time study was completed in order to more precisely determine the man-hour requirement for a representative component using the LTCPC process

- Man-hour estimates for the management and handling of hazardous waste generated by the process
    - Reason: An extensive application time study was completed in order to more precisely determine the man-hour requirement for a representative component
- Civilian labor rate associated with each process' man-hour requirement
    - Reason: Facility stakeholders provided current estimates of their fully burdened labor rates
- Quantity of masking required for the representative component
    - Reason: Facility stakeholders stated that the amount of masking required would remain constant when transitioning from wet coatings to LTCPC
- Unit purchase cost of LTCPC material
    - Reason: Facility stakeholders provided current estimates for LTCPC cost taking volume purchase discounts into consideration

7.2 COST ANALYSIS AND COMPARISON

7.2.1 LTCPC Primary Cost Element Categories

7.2.1.1 Facility Capital

Facility capital encompasses initial costs associated with the acquisition of land and equipment, the construction or modification of buildings, as well as the support services associated with these expenditures. LTCPC facility capital costs include the purchase of any Commercial-Off-The-Shelf (COTS) powder coating equipment such as an electrostatic powder gun, powder delivery and storage system, powder spray booth, or curing oven not currently in place at depot facilities.

7.2.1.2 Start-up and Operations & Maintenance

Start-up costs are defined as the various expenses, excluding facility capital, that are necessary to bring a new process into a production-ready state. Start-up costs related to LTCPC operations will be negligible, consisting mainly of initial operator checkout and setup. As the name implies, operations and maintenance costs include all of the expenses associated with ensuring the availability and reliability of process equipment during its use.

Improved coating transfer efficiency lowers the volume of material required for coating a given surface area. Transitioning to powder coating will result in lower direct material costs than continuing to use solvent-based coatings. In addition, LTCPC labor hours are anticipated to decrease with the elimination of labor-intensive procedures such as the mixing and application of multi-component primers and topcoats. Utilities consumption has the potential to either increase or decrease based upon the coating process currently in use for each identified component.

7.2.1.3 Equipment Replacement

Equipment replacement encompasses the replacement of any limited lifespan components associated with the powder coating system. The magnitude of LTCPC equipment replacement is expected to remain unchanged relative to the baseline process' costs.

7.2.1.4 ESOH and Cost Avoidance

Changes made to a production line can positively or negatively impact the existing ESOH costs associated with the process. The immediate and potential impacts of proposed modifications must be considered across the expected lifespan of the process. Powder coatings such as LTCPC are applied to components in solid form allowing for VOC and HAP-free application. Elimination of VOC and HAP emissions will slightly decrease the costs related to permitting, monitoring, and reporting requirements.

7.2.1.5 Reprocessing/Reapplication

There are no projected reprocessing costs since LTCPC will act as a direct replacement for the baseline coatings during each facility's typical material application schedule, which includes scheduled maintenance cycles. DoD stakeholders also require that the durability of any transitioned coating to be as good as the coating it is replacing, therefore periodic reapplication costs are not expected to increase.

7.2.1.6 Hazardous Waste Storage and Disposal

Each facility monitors current rates for the storage and disposal of hazardous waste associated with solvent based paints. As designed, LTCPC eliminates the production of hazardous waste streams during painting operations.

7.2.2 Life Cycle Costs Comparison

For the purposes of cost comparison, the baseline process consists of multi-layer paint systems utilizing wet primers and topcoats while the innovative replacement is the low temperature cure powder coating with no primer.

Table 58. LTCPC Life Cycle Costs by Category

ECAM LEVEL I				ECAM LEVEL II	
Direct Activity Costs				Indirect Environmental Activity Costs	
Start-Up		Operations & Maintenance			
Activity	Cost	Activity	Cost	Activity	Cost
Equipment Purchase – Powder Coating System	$ 4,895	Powder Coating Applied to Substrate	$ 281	Maintenance of Environmental Equipment and Facilities	$ 4,804
Equipment Purchase – Powder Coating Booth	$28,790	Masking Required for Substrates	$ 294	Development of In-House Training Materials	$ 1,457
Equipment Purchase – Curing Oven (electric)	$50,925	Required Personal Protection Equipment	$ 3,825	Fees to Maintain Permits	$ 500
Equipment Purchase – Environmental Controls System for PC Room	$20,995	Utilities (Electricity for Painting Operations)	$ 328	Labor for Internal Audit Teams	$ 316
Initial Training of Operators (Powder Coating)	$ 2,002	Labor for Powder Application	$ 16,422	Completion of Audit Reports	$ 644
Development of Internal Audit Checklists and Documents	$ 80	Equipment Maintenance	$ 1,000	Off-Site Waste Treatment and Disposal	$ 185
		Periodic Training of Operators (New Hires, Refresher Course)	$ 13,933	Completion of Miscellaneous Documentation Activities	$ 10,581
				Annual Physicals and Fit Testing	$ 751
Total	**$ 107,687**	**Total**	**$ 36,083**	**Total**	**$ 19,238**

Table 59. Baseline Process Life Cycle Costs by Category

ECAM LEVEL I				ECAM LEVEL II	
Direct Activity Costs				Indirect Environmental Activity Costs	
Start-Up		Operations & Maintenance			
Activity	Cost	Activity	Cost	Activity	Cost
SUNK COSTS UNDER CURRENT PROCESS		Wet Primer Applied to Substrate	$1,188	Maintenance of Environmental Equipment and Facilities	$ 4,804
		Wet Topcoat Applied to Substrate	$ 2,393	Development of In-House Training Materials	$ 1,457
		Paint Thinner Used for Primer and Cleaning	$ 630	Fees to Maintain Permits	$ 500
		Filters for Spray Booth Particulate Matter	$ 3,624	Labor for Internal Audit Teams	$ 316
		Masking Required for Substrates	$ 294	Completion of Audit Reports	$ 644
		Required Personal Protection Equipment	$ 27,095	Off-Site Waste Treatment and Disposal	$ 651
		Utilities (Electricity for Painting Operations)	$ 205	Labor to Handle, Transport, and Store Hazardous Waste On-Site	$ 2,875
		Labor for Wet Primer Application	$ 69,564	Completion of Miscellaneous Documentation Activities	$ 12,260
		Labor for Wet Topcoat Application	$ 5,814	Annual Physicals and Fit Testing	$ 751
		Labor to Containerize the Process' Hazardous Waste	$ 19,125		
		Equipment Maintenance	$ 1,000		
		Periodic Training of Operators (New Hires, Refresher Course)	$ 12,652		
		Total	**$ 143,584**	**Total**	**$ 24,258**

Net Present Value (NPV) calculations used December 2008 Office of Management and Budget (OMB) discount rates of 2.4% and 2.9% based upon ECAM study periods of 10 and 20 years, respectively. These discount rates account for the time value of money and permit the estimation of life-cycle cost savings for a DoD facility implementation of LTCPC. Expected Life-Cycle Cost savings are presented by funding source and study timeframe within Tables 64 through 71.

Table 60. LCC Savings for LTCPC Implementation – Overall, 20 Years

Fiscal Year	2006	2007	2008	2009	2010	2011	2012	2013 thru 2030	2031
Acct. Year	-5	-4	-3	-2	-1	0	1	2 thru 19	20
Benefits						$197K	$788K	$788K / year	$788K
Costs	$472K	$655K	$503K	$306K	$ -	$754K			

Present Benefits = $ 12,024,000
Present Costs = $ 2,904,000
LCC Savings = $ 9,120,000

Table 61. LCC Savings for LTCPC Implementation – USAF, 20 Years

Fiscal Year	2006	2007	2008	2009	2010	2011	2012	2013 thru 2030	2031
Acct. Year	-5	-4	-3	-2	-1	0	1	2 thru 19	20
Benefits						$84K	$338K	$338K / year	$338K
Costs	$ -	$350K	$200K	$200K	$ -	$323K			

Present Benefits = $ 5,153,000
Present Costs = $ 1,145,000
LCC Savings = $ 4,008,000

Table 62. LCC Savings for LTCPC Implementation – USN, 20 Years

Fiscal Year	2006	2007	2008	2009	2010	2011	2012	2013 thru 2030	2031
Acct. Year	-5	-4	-3	-2	-1	0	1	2 thru 19	20
Benefits						$113K	$450K	$450K / year	$450K
Costs	$ -	$ -	$ -	$ -	$ -	$431K			

Present Benefits = $ 6,871,000
Present Costs = $ 431,000
LCC Savings = $ 6,440,000

Table 63. LCC Savings for LTCPC Implementation – Overall, 10 Years

Fiscal Year	2006	2007	2008	2009	2010	2011	2012	2013 thru 2020	2021
Acct. Year	-5	-4	-3	-2	-1	0	1	2 thru 9	10
Benefits						$197K	$788K	$788K / year	$788K
Costs	$472K	$655K	$503K	$306K	$ -	$754K			

Present Benefits = $ 7,126,000
Present Costs = $ 2,866,000
LCC Savings = $ 4,260,000

Table 64. LCC Savings for LTCPC Implementation – USAF, 10 Years

Fiscal Year	2006	2007	2008	2009	2010	2011	2012	2013 thru 2020	2021
Acct. Year	-5	-4	-3	-2	-1	0	1	2 thru 9	10
Benefits						$84K	$338K	$338K / year	$338K
Costs	$ -	$350K	$200K	$200K	$ -	$323K			

Present Benefits = $ 3,054,000
Present Costs = $ 1,132,000
LCC Savings = $ 1,922,000

Table 65. LCC Savings for LTCPC Implementation – USN, 10 Years

Fiscal Year	2006	2007	2008	2009	2010	2011	2012	2013 thru 2020	2021
Acct. Year	-5	-4	-3	-2	-1	0	1	2 thru 9	10
Benefits						$113K	$450K	$450K / year	$450K
Costs	$ -	$ -	$ -	$ -	$ -	$431K			

Present Benefits = $ 4,072,000
Present Costs = $ 431,000
LCC Savings = $ 3,621 ,000

7.2.3 Life Cycle Costs Assessment

Evaluation of LTCPC's LCC savings suggests that implementation will result in significant cost savings for both the USAF and USN over each of the study timeframes. NPV calculations suggest USAF savings of $1.9 million after utilizing LTCPC for 10 years and $4.0 million after 20 years. Likewise, NPV calculations identify approximately $3.6 million in savings for the USN over 10 years and $6.4 million over 20 years. Additionally, the combined LCC savings realized for ESTCP's contributions are expected to be roughly $5.8 million in the first 10 years and $10.7 million over 20 years. All project expenditures as well as the expected annual cost savings for fiscal years 2011 through 2021 (or 2031) are identified in Tables 64 through 71.

A second commonly-used financial indicator is simple payback. By definition, simple payback doesn't take the time value of money into consideration but it provides decision makers with an easily calculated financial metric. As such, this metric is not affected by changes in discount rates associated with evaluating multiple time periods. An overall payback period of 3.4 years is projected for the process savings associated with transitioning LTCPC to the various Air Force and Navy primary maintenance facilities. There is also an expected payback period of 1.5 years for the portion of funding contributed by ESTCP. Individually, the USAF and USN can anticipate payback periods of 3.2 and 1.0 years, respectively.

Another indicator utilized to evaluate the financial attractiveness of alternatives is the Internal Rate of Return (IRR). The alternative under consideration is preferred in those instances where the alternative's IRR exceeds the accepted secondary investment strategy, which for the US government is represented by the appropriate OMB discount rate. Overall IRRs for the LTCPC project over 10 and 20 years are 15.5% and 18.8%, respectively, while IRR estimates for ESTCP's investment in LTCPC are 25.4% and 26.7%. USAF IRRs are projected to be 17.9% over 10 years and 20.4% over 20 years. Lastly, it should be noted that the IRRs calculated for the USN, 141.4% for both timeframes, are much larger than the previous values as a result of the USN not contributing any LTCPC project funding.

Review of the CBA data reveals that the major cost drivers associated with traditional wet coatings are: (1) the length of material cure times, (2) the magnitude of generated hazardous waste, and (3) the magnitude of required PPE purchases. These cost drivers increase both labor and material application costs while also raising the component's overall process flow time. In turn the increased process flow time negatively impacts repaired component delivery schedules that can indirectly reduce overall mission readiness.

8.0 IMPLEMENTATION ISSUES

8.1 IMPLEMENTATION STAKEHOLDERS

Within the Navy, the following individuals and organizations with expansive implementation authority have been identified for the targeted components.

NAVAIR GSE – David Piatkowski

In contrast, the Air Force assigns implementation authority to the individual weapon system level engineers at each program office.

8.2 LTCPC ACCEPTANCE PROCESS

Stakeholder acceptance of LTCPC as a viable replacement is based upon the results of laboratory and real-world material performance testing outlined within this final report. In that respect, during the FSE period LTCPC color and gloss were determined to be inconclusive based upon the reported values. However, after careful consideration of earlier laboratory tests, project stakeholders anticipate there will be no impact to LTCPC implementation based upon these inconclusive results. Technology implementation at depot facilities will occur once engineering approvals have been granted to change the technical orders/manuals associated with this process and LTCPC has been added to an appropriate Qualified Product Database (QPD). In addition, discussion of LTCPC will need to be added to appropriate specifications such as MIL-PRF-24712 and SAE AMS 3143A. Technology implementation at field locations will not require new equipment but will require assurance of compatibility with wet coating repair procedures.

8.3 IMPACT OF ESOH REGULATIONS

The LTCPC material contains a barium metaborate corrosion inhibitor package. The EPA has indicated that standard PPE including a dust mask is all that is required. The MSDS for the LTCPC lists the PEL for this material at $5 mg/m^3$, and recommends long-sleeved shirt, full-length trousers, impervious gloves, safety glasses with side shields, and a NIOSH approved dust respirator. Bioenvironmental personnel at Hill AFB have reviewed barium metaborate and have concurred with the assessment. Laboratory Toxicity Characteristic Leaching Procedure (TCLP) testing confirmed the leachable barium concentration is below the level requiring classification as a characteristic hazardous waste, so any unused and waste powder can be disposed of as ordinary waste.

Powder coating of aircraft components is regulated under the Aerospace Manufacturing and Rework NESHAP (40 CFR 63, Subpart GG); however compliance will not be an issue due to the low VOC and HAP content of LTCPC. The EPA is currently developing proposed rules for a Defense Land Systems and Miscellaneous Equipment NESHAP that would apply to defense items not applicable under Aerospace and Shipbuilding NESHAPs. As with the Aerospace NESHAP, future compliance is not expected to be a problem for the use of low temperature cure powder.

In addition to the presence of trace amounts of leachable barium in the uncured powder, the powder is ground to sufficiently fine particle size (average particle size is between 30 and 35 microns) that appropriate PPE will be required to avoid nuisance dust inhalation effects. This fine particle size also requires that precautions be taken (in the form of adequate air handling) to avoid a buildup of potentially explosive dust. Additionally, the powder coating crosslinker, TGIC, is a toxic chemical. Therefore, inhalation exposure to LTCPC dust should be minimized to the largest extent possible for worker safety. However, these preventative measures are not atypical of routine precautions taken with any other powder coating material. Other than the current and potential NESHAPs mentioned the previous paragraph, there are no other known regulations that apply to powder coatings.

8.4 LTCPC PROCUREMENT

8.4.1 Process Equipment

Depot facilities wanting to utilize LTCPC would be required to purchase any COTS powder coating equipment such as an electrostatic powder gun, powder delivery and storage system, powder spray booth, and curing oven that is not currently in place. The technology associated with LTCPC has not been modified from its COTS state for the purposes of this demonstration.

8.4.2 Production and Scale-Up

Size-dependent costs associated with the construction and operation of convention curing ovens generate the only significant constraint to production and scale-up of this technology. Based upon localized inputs, each facility will need to determine the size (break-even point) at which the costs associated with an increase in oven capacity would outweigh the added benefits.

With respect to product manufacturing, economies of scale will reduce the per-pound cost once Air Force and Navy depot requirements for low temperature cure powder coatings are increased.

8.4.3 Proprietary and Intellectual Property Rights

As designed, there are no proprietary or intellectual property rights associated with the LTCPC technology.

8.5 TECHNOLOGY TRANSFER EFFORTS

Although this coating material will not be used on a wide scale initially, Air Force and Navy acceptance will increase LTCPC usage through the modification of specifications and technical orders regarding approved coatings. This will facilitate adoption of the process by other services and original equipment manufacturers.

Stakeholders originally considered revising the military performance specification, MIL-PRF-24712A “Coatings, Powder (Metric)”, to more accurately reflect the current performance and range of powder coating materials that are available today. However, after research and further discussion it was decided that a revision of industry specification, SAE AMS 4134A “Powder Coating Materials, Epoxy”, could be accomplished in a shorter timeframe. At the same time, stakeholders advocated for the inclusion of language supporting the use of LTCPC within applicable general series and weapon system level technical orders and manuals.

In addition to the previously identified military uses for low temperature cure powder coatings, technology transition opportunities exist within general aviation and other industries looking to reduce existing powder cure energy requirements or to apply uniform, high-performance coatings to temperature-sensitive substrates. The technology associated with LTCPC has not been modified for the purposes of this demonstration. Therefore barring designation as a proprietary defense technology, there is no reason to believe that this SERDP and ESTCP-developed technology cannot be transitioned to the private sector.

9.0 REFERENCES

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APPENDICES

APPENDIX A: POINTS OF CONTACT

The following individuals contributed significant time and effort in support of the LTCPC project, acting as primary stakeholders and technical resources.

Table 66. LTCPC POC List

POINT OF CONTACT Name	ORGANIZATION Name Address	Phone Fax E-mail	Role in Project
Warren Assink	HQ AFMC/A4DM WPAFB, OH	(937) 904-0151 warren.assink@wpafb.af.mil	ESTCP Project Manager
Steven Battle	402 MXW/QPE WR-ALC Robins AFB, GA	steven.battle@robins.af.mil	Dem/Val Site Coordinator – C-130
Stephen Castiglia	CTC WPAFB, OH	(937) 656-3688 stephen.castiglia@wpafb.af.mil	Technical Project Manager
James Davila	SAIC WPAFB, OH	(937) 431-2272 (937) 431-2288 james.a.davila@saic.com	Project Manager
Christopher Geib	SAIC WPAFB, OH	(937) 431-4332 (937) 431-2288 christopher.w.geib@saic.com	Technical Support
Dana Kaminsky	NAVAIR Code 434 Lakehurst, NJ	(732) 323- dana.kaminsky@navy.mil	Dem/Val Site Coordinator – GSE
Pattie Lewis	NASA TEERM Principal Center KSC, FL	pattie.lewis-1@ksc.nasa.gov	NASA Requirements Technical Lead
Chris Mahendra	NAVAIR Code 486J Lakehurst, NJ	(732) 323-7131 christopher.mahendra@navy.mil	Navy Technical Manager
Wayne Patterson	809 MXSS/MXRL OO-ALC Hill AFB, UT	(801) 775-2992 wayne.patterson@hill.af.mil	Air Force Principal Investigator
David Piatkowski	NAVAIR Code 434 Lakehurst, NJ	(732) 323-2716 (732) 323-5269 david.piatkowski@navy.mil	Navy Principal Investigator / Ground Support Coordinator

APPENDIX B: REFERENCE DOCUMENTS

The following materials, processing, performance and testing documents and standards are referenced within this Final Report.

Table 67. Reference Documents

Reference Document	Title	Applicable Sections	Final Report Sections
ASTM B 117	Standard Practice for Operating Salt Spray (Fog) Apparatus	All	3.0, 5.1.1, 5.1.3.2, 5.1.4.1
ASTM D 522	Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings	Test Method A	5.1.1, 5.1.4.2
		Test Method B	3.0, 3.1.1.9, 5.1.1, 5.1.4.6
ASTM D 523	Standard Test Method for Specular Gloss	60° Geometry	3.0, 5.1.1
ASTM D 610	Standard Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces		3.0, 5.1.1
ASTM D 714	Standard Test Method for Evaluating Degree of Blistering of Paints		3.0, 5.1.1, 5.1.3.2, 5.1.3.4
ASTM D 823	Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels		5.1.2.3.1 **thru** 5.1.2.3.5
ASTM D 1654	Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments	Procedure A, Method 1 (Air Blow Off)	3.0, 5.1.1, 5.1.3.2, 5.1.3.3, 5.1.3.4, 6.1.2.4
ASTM D 2244	Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates	CIELAB Metric	3.0, 5.1.1, 5.1.3.1
ASTM D 2803	Standard Guide for Testing Filiform Corrosion Resistance of Organic Coatings on Metal	Procedure C	3.0, 5.1.1, 5.1.3.5
ASTM D 3170	Standard Test Method for Chipping Resistance of Coatings		5.1.1, 5.1.4.5, 6.1.3.5
ASTM D 3359	Standard Test Methods for Measuring Adhesion by Tape Test	Test Method B	3.0, 5.1.1, 5.1.3.6, 6.1.2.6

Reference Document	Title	Applicable Sections	Final Report Sections
ASTM D 6905	Standard Test Method for Impact Flexibility of Organic Coatings	All	3.0, 5.1.1, 5.1.3.7, 6.1.2.7
ASTM D 7091	Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals		3.0
ASTM E 595	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment		5.1.1, 5.1.4.3
ASTM G 85	Standard Practice for Modified Salt Spray (Fog) Testing	Annex 4	3.0, 5.1.1, 5.1.3.3
CLG-LP-043 Revision 0	Strippability (Chemical Strippers)		5.1.1, 5.1.3.8
FED-STD-141D	Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing	Method 6301.3	3.0, 5.1.1, 5.1.3.6
FED-STD-595B	Colors used in Government Procurement	17925, Gloss White	3.0, 5.1.1, 5.1.2.2.1 **thru** 5.1.2.2.4, 5.1.2.3.1, 5.1.2.3.2, 5.1.2.3.3, 5.1.3.1, 5.1.4.3
GM 4465P	Water Fog Humidity Test		3.0, 5.1.1, 5.1.3.4
GM 9540P	Accelerated Corrosion Test	All	3.0, 5.1.1, 5.1.3.4, 6.1.2.4
MIL-A-8625	Anodic Coatings for Aluminum and Aluminum Alloys	Type I or IC	5.1.2.2.2, 5.1.2.3.3
MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys	Class 1A	5.1.2.2.1, 5.1.2.3.1
MIL-C-8514	Coating Compound, Metal Pretreatment, Resin-Acid	All	5.1.2.3.2

Reference Document	Title	Applicable Sections	Final Report Sections
MIL-DTL-5624	Detail Specification, Turbine Fuel, Aviation, Grades JP-4 and JP-5		5.1.4.4, 6.1.3.4
MIL-L-23699 (currently MIL-PRF-23699F)	Performance Specification, Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number O-156		5.1.4.4, 6.1.3.4
MIL-P-53022B	Primer, Epoxy Coating, Corrosion Inhibiting, Lead and Chromate Free	Type II	4.2, 5.1.2.3.5, 6.1.2.2, 6.1.2.3, 6.1.2.4, 6.1.2.6, 6.1.2.8, 6.1.3.4, 6.1.3.5
MIL-PRF-23377J	Primer Coatings: Epoxy, High-Solids	All	1.3, 3.0, 3.1.1.2, 4.2, 5.1.2.3.1, 5.1.2.3.4, 5.1.4.1, 6.1.1, 6.1.2.1 **thru** 6.1.2.6, 6.1.2.8, 6.1.3.6
MIL-PRF-83282	Performance Specification, Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Metric, NATO Code Number H-537		5.1.4.4, 6.1.3.4
MIL-PRF-85285D	Coating: Polyurethane, Aircraft And Support Equipment	All	3.0, 3.1.1.8, 4.2, 5.1.1, 5.1.2.3.1 **thru** 5.1.2.3.5, 5.1.4.4, 6.1.2.1 **thru** 6.1.2.8, 6.1.3.4, 6.1.3.5, 6.1.3.6
MIL-R-81294D	Remover, Paint, Epoxy, Polysulfide, and Polyurethane Systems		5.1.3.8
NASA-STD-6001	Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion		5.1.1, 5.1.4.3
Rockwell Spec MB0125-055	Primer, Epoxy Amine, Corrosion Room Preventative Room Temperature Curing		5.1.4.2
SAE AMS-1640	Compound, Corrosion Removing for Aircraft Surfaces		5.1.2.2.1, 5.1.2.3.1, 5.1.2.3.2

Reference Document	Title	Applicable Sections	Final Report Sections
SAE AMS-4375	Sheet and Plate, Magnesium Alloy 3.0Al-1.0Zn-0.20Mn (AZ31B) Annealed and Recrystallized		5.1.2
SAE AMS-6350	Steel Sheet, Strip, and Plate, 0.95Cr - 0.20Mo (0.28 - 0.33C) (SAE 4130), Annealed		5.1.2
SAE AMS-M-3171	Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion on	Type III – Dichromate Treatment	5.1.2.2.3, 5.1.2.3.4
SAE AMS-QQ-A-250/4	Aluminum Alloy 2024, Plate and Sheet		5.1.2
SAE AMS-QQ-A-250/5	Aluminum Alloy Alclad 2024, Plate and Sheet		5.1.2
SAE AMS-QQ-A-250/11	Aluminum Alloy 6061, Plate and Sheet		5.1.2
SAE AMS-QQ-A-250/12	Aluminum Alloy 7075, Plate and Sheet		5.1.2
SP-R-0022A	General Specification Vacuum Stability Requirements of Polymeric Material for Spaceport Application	Addendum 1	5.1.1, 5.1.4.3
TO 1-1-8	Application and Removal of Organic Coatings, Aerospace and Non-Aerospace Equipment		1.2, 4.2.1.1, 5.1.1, 5.1.3.8
TT-C-490E	Chemical Conversion Coatings and Pretreatments for Ferrous Surfaces (Base for Organic Coatings)	Type II	5.1.2.2.4, 5.1.2.3.5

APPENDIX C: TEST COUPON QUANTITIES

Table 68. Coupon Quantities (LTCPC & Control)

Test	Substrate								
LTCPC / Controls	**Al-1**	**Al-2**	**Al-3**	**Al-4**	**Al-5**	**Al-6**	**Al-7**	**Mg**	**ST**
Coating Appearance and Quality			3 / 0					3 / 0	3 / 0
Neutral Salt Fog Corrosion Resistance		6 / 3	6 / 3		3 / 0			6 / 3	6 / 3
SO_2 Salt Fog Corrosion Resistance		6 / 3	6 / 3						6 / 3
Cyclic Corrosion Resistance				3 / 3					3 / 3
Filiform Corrosion Resistance				3 / 6					
Cross-Cut Adhesion by Tape			3* / 3					3* / 3	0* / 3
Impact Flexibility	3 / 3								
Strippability		6 / 6	6 / 6	6 / 6				3 / 3	6 / 6
NASA Extreme Temperature Flexibility						8 / 0			
NASA Outgassing							8 / 0		
Fluids Resistance		9 / 0							
Chipping Resistance		3 / 3							
Low Temperature Flexibility		4 / 0							
Total	**3 / 3**	**34 / 15**	**24 / 15**	**12 / 15**	**3 / 0**	**8 / 0**	**8 / 0**	**15 / 9**	**24 / 18**
Combined Total	**6**	**49**	**39**	**27**	**3**	**8**	**8**	**24**	**42**

* LTCPC coupons produced for Coating Appearance and Quality also used for tape adhesion tests

APPENDIX D: JTP RAW TEST DATASHEETS

Table 69. Thickness, Tape Adhesion, and Strippability Raw Data

WP0614 Sample Labeling

Sample Number			Substrate	Pretreatment	Primer	Top Coat		Salt Fog	Hours to failure in salt fog	SO2	Cyclic	Filiform	Adhesion	Panel numbers failed Salt FOG	Adhesion Test		Thickness	Benzyl Alcohol Peroxide	Type V Plastic	GPX
								Number of test coupons										Stripability		
	1	St	4130 Steel	no pretreat	No Prime	LTCPC					3		3		Pass	5B	1.7	2-4 hours	<3 Min	<3 Min
	2	St	4130 Steel	no pretreat	No Prime	LTCPC		3	264	3				2B,2C,2D Air Bubbles	Fail	2B	1.1	2-4 hours	<3 Min	<3 Min
	3	St	4130 Steel	Fe Phos	53022 B	85285 Top Coat					3		3		Pass	5B	3	2-4 hours	<3 Min	<3 Min
	4	St	4130 Steel	Fe Phos	53022 B	85285 Top Coat		3		3					Pass	4B	2.6	2-4 hours	<3 Min	<3 Min
4A		St	4130 Steel	Mn Phos	53022 B	85285 Top Coat		3		3								2-4 hours	<3 Min	<3 Min
	5	St	4130 Steel	Fe Phos	No Prime	LTCPC		3	*264	3				*5CAir Bubbles failed at this time	Pass	5B	1.2	2-4 hours	<3 Min	<3 Min
5A		St	4130 Steel	Mn Phos	No Prime	LTCPC		3	*264	3								2-4 hours	<3 Min	<3 Min
	6	St	4130 Steel	Fe Phos		LTCPC					3		3		Pass	5B	2.1	2-4 hours	<3 Min	<3 Min
	7	Al-2	2024 T-3 Bare	Alodine	23377		85285	3		3					Pass	5B	3	2-4 hours	<3 Min	<3 Min
	8	Al-2	2024 T-3 Bare	Alodine		LTCPC		3		3					Pass	5B	2.5	2-4 hours	<3 Min	<3 Min
	9	Al-2	2024 T-3 Bare			LTCPC		3		3					fail	1B	3.1	2-4 hours	<3 Min	<3 Min
	10	Al-3a	6060 T-6	Alodine		LTCPC		3		3					Pass	5B	1.8	2-4 hours	<3 Min	<3 Min
	11	Al-3a	6060 T-6			LTCPC		3		3					Pass	5B	2	2-4 hours	<3 Min	<3 Min
	12	Al-3a	6060 T-6	Alodine	23377		85285	3		3					Pass	5B	2.5	2-4 hours	<3 Min	<3 Min
	13	Al-4	2024 T-3 Clad	Alodine		LTCPC					3	3			Pass	5B	1.7	2-4 hours	<3 Min	<3 Min
	14	Al-4	2024 T-3 Clad				85285				3	3			fail	0B	3.1	2-4 hours	<3 Min	<3 Min
	15	Al-4	2024 T-3 Clad			LTCPC					3	3			Pass	4B	2.1	2-4 hours	<3 Min	<3 Min
	16	Al-3	6061 T-6	Alodine		LTCPC		3		3					Pass	5B	1.8	2-4 hours	<3 Min	<3 Min
	17	Al-3	6061 T-6	PreKote		LTCPC		3		3					Pass	5B	2.3	2-4 hours	<3 Min	<3 Min
	18	Al-3	6061 T-6	Alodine	23377		85285	3		3					Pass	5B	2.2	2-4 hours	<3 Min	<3 Min
	19	Mg	MG AZ31B	DOW	23377		85285	3					3		Pass	5B	2.3	2-4 hours	<3 Min	<3 Min
	20	Mg	MG AZ31B	DOW		LTCPC		3					3		Pass	5B	2	2-4 hours	<3 Min	<3 Min
	21	Mg	MG AZ31B	No Pretreat		LTCPC		3	24				3		3b	5B	2.1	2-4 hours	<3 Min	<3 Min
	22	Mg	MG AZ31B	DOW/PreKote		LTCPC		3					3		Pass	5B	1.9	2-4 hours	<3 Min	<3 Min
	23	AL	7075 T-6			LTCPC		3												
						Total Samples		57		42	18	9	21							

LTCPC--Low Temperature cure Powder Coating--Cross Link

Note Sample Number is followed by a letter designating its place on the original panel

Table 70. Cyclic Corrosion Resistance Raw Data – Aluminum

Corrosion Evaluation Report - Specimens Subjected to Corrosive Environments

Exposure Method: GM9540 | Project ID: 014421.036.000.CI.0008 | Analyst: TH

				RATING ACCORDING TO ASTM D 1654							
				Scribed Area				Unscribed Area			
Sample ID	Test Period (hrs)	Date Evaluated	Specimen Description/ Base Material	Average Creepage Rating at Scribe † (0-10)	Maximum Creepage Rating at Scribe † (0-10)	Minimum Creepage Rating at Scribe † (0-10)	Interval of Noticeable Adhesion Loss/ Corrosion * (hrs)	Rating at Unscribed Area † (0-10)	Interval of Noticeable Red Rust/ Corrosion * (hrs)	No. of Pits (where applicable) *	Corrosion Type *
07-1673-P	1920	5/22/2007	Panel # 13-B (Alclad 2024-T3 Al)	9	8	10	1174-1339	10	NC	NA	No Corrosion
07-1674-P	1920	5/22/2007	Panel # 14-B (Al)	9	7	10	0-196	10	NC	NA	No Corrosion
07-1675-P	1920	5/22/2007	Panel # 15-B (Alclad 2024-T3 Al)	9	7	10	383-624	10	NC	NA	No Corrosion
07-1678-P	1920	5/22/2007	Panel # 13-C (Alclad 2024-T3 Al)	9	7	10	1339-1771	10	NC	NA	No Corrosion
07-1679-P	1920	5/22/2007	Panel # 14-C (85285 on Al)	8	7	10	196-383	9	965-1174	NA	Blisters
07-1680-P	1920	5/22/2007	Panel #15-C (powder on Alclad 2024-T3 Al)	9	7	10	624-937	10	NC	NA	No Corrosion
07-1683-P	1920	5/22/2007	Panel #13-D (powder on Alclad 2024-T3 Al)	9	8	10	624-937	10	NC	NA	No Corrosion
07-1684-P	1920	5/22/2007	Panel # 14-D (Al)	8	7	10	956-1174	10	NC	NA	No Corrosion
07-1685-P	1920	5/22/2007	Panel #15-D (powder on Alclad 2024-T3 Al)	8	5	10	0-196	10	NC	NA	No Corrosion

† Table 1: Rating of Failure (From ASTM D 1654)

Scribe Rating			Unscribe Rating
Millimeters	Inches	Rating No.	Area Failed, %
Zero	0	10	No Failure
Over 0 to 0.5	0 to 1/64	9	0 to 1
Over 0.5 to 1.0	1/64 to 1/32	8	2 to 3
Over 1.0 to 2.0	1/32 to 1/16	7	4 to 6
Over 2.0 to 3.0	1/16 to 1/8	6	7 to 10
Over 3.0 to 5.0	1/8 to 3/16	5	11 to 20
Over 5.0 to 7.0	3/16 to 1/4	4	21 to 30
Over 7.0 to 10.0	1/4 to 3/8	3	31 to 40
Over 10.0 to 13.0	3/8 to 1/2	2	41 to 55
Over 13.0 to 16.0	1/2 to 5/8	1	56 to 75
Over 16.0	5/8 +	0	Over 75

* Table 2: Description of Corrosion Codes

# - #	Organic Coatings - First loss of adhesion/ blistering occurred between these inspection intervals. Inorganic Coatings - First sign of corrosion type occurred between these inspection intervals.
NL	No Loss of adhesion (blistering)
NN	No Noticeable adhesion loss (blistering) during exposure period
NA	Not Applicable
NC	No Corrosion
TNTC	To Numerous To Count
+	Exceeding Maximum Allowable Spot Diameter
WCP	White Corrosion Products
BCP	Black Corrosion Products
GCP	Green Corrosion Products
RCP	Red Corrosion Products
RR	Red Rust

Reviewed By: | Date:

Table 71. Cyclic Corrosion Resistance Raw Data – Steel

Corrosion Evaluation Report - Specimens Subjected to Corrosive Environments

Exposure Method: GM 9540 | Project ID: 01442.1.036.000.CJ.0008 | Analyst: TH

				RATING ACCORDING TO ASTM D 1654							
				Scribed Area				Unscribed Area			
Sample ID	Test Period (hrs)	Date Evaluated	Specimen Description/ Base Material	Average Creepage Rating at Scribe † (0-10)	Maximum Creepage Rating at Scribe † (0-10)	Minimum Creepage Rating at Scribe † (0-10)	Interval of Noticeable Adhesion Loss/ Corrosion * (hrs)	Rating at Unscribed Area † (0-10)	Interval of Noticeable Red Rust/ Corrosion * (hrs)	No. of Pits (where applicable) *	Corrosion Type *
07-1671-P	1920	7/20/2007	Panel #3-A (steel)	7	4	10	744-984	10	NC	NA	No Corrosion
07-1672-P	1920	7/20/2007	Panel #3-B (steel)	7	4	10	744-984	9	0-185	NA	Red Rust
07-1676-P	1920	7/20/2007	Panel #3-C (steel)	8	6	10	185-576	10	NC	NA	No Corrosion
07-1677-P	1920	7/20/2007	Panel #6-A (steel)	6	4	10	185-576	10	NC	NA	No Corrosion
07-1681-P	1920	7/20/2007	Panel #6-B (steel)	7	5	10	185-576	9	576-744	NA	Blisters, Red Rust
07-1682-P	1920	7/20/2007	Panel #6-C (steel)	6	3	10	185-576	9	744-984	NA	Blister, Red Rust

† Table 1: Rating of Failure (From ASTM D1654)

Scribe Rating			Unscribe Rating
Millimeters	Inches	Rating No.	Area Failed, %
Zero	0	10	No Failure
Over 0 to 0.5	0 to 1/64	9	0 to 1
Over 0.5 to 1.0	1/64 to 1/32	8	2 to 3
Over 1.0 to 2.0	1/32 to 1/16	7	4 to 6
Over 2.0 to 3.0	1/16 to 1/8	6	7 to 10
Over 3.0 to 5.0	1/8 to 3/16	5	11 to 20
Over 5.0 to 7.0	3/16 to 1/4	4	21 to 30
Over 7.0 to 10.0	1/4 to 3/8	3	31 to 40
Over 10.0 to 13.0	3/8 to 1/2	2	41 to 55
Over 13.0 to 16.0	1/2 to 5/8	1	56 to 75
Over 16.0	5/8 +	0	Over 75

* Table 2: Description of Corrosion Codes

# - #	Organic Coatings - First loss of adhesion/ blistering occurred between these inspection intervals. Inorganic Coatings - First sign of corrosion type occurred between these inspection intervals.
NL	No Loss of adhesion (blistering)
NN	No Noticeable adhesion loss (blistering) during exposure period
NA	Not Applicable
NC	No Corrosion
TNTC	To Numerous To Count
+	Exceeding Maximum Allowable Spot Diameter
WCP	White Corrosion Products
BCP	Black Corrosion Products
GCP	Green Corrosion Products
RCP	Red Corrosion Products
RR	Red Rust

Reviewed By:	Date:

Table 72. Filiform Corrosion Resistance Raw Data

Corrosion Evaluation Report - Specimens Subjected to Corrosive Environments

Exposure Method:MIL-PRF-85582, Section 3.7.2.2 | Project ID: 01442.1.036.000.CJ.0008 | Analyst: TH

				RATING ACCORDING TO ASTM D 2803							
				Scribed Area				Unscribed Area			
Sample ID	Test Period (hrs)	Date Evaluated	Specimen Description/ Base Material	Number of Filaments	Minimum Length of Filaments (inch)	Maximum Length of Filaments (inch)	Interval of Noticeable Adhesion Loss/ Corrosion * (hrs)	Rating at Unscribed Area † (0-10)	Interval of Noticeable Red Rust/ Corrosion * (hrs)	No. of Pits (where applicable) *	Corrosion Type *
07-1689-P	1000	3/28/2007	Panel #13-E	TNTC	1/16	9/32	NA	NA	NA	NA	NA
07-1690-P	1000	3/28/2007	Panel #13-F	TNTC	1/8	3/8	NA	NA	NA	NA	NA
07-1691-P	1000	3/28/2007	Panel #13-G	TNTC	1/16	3/16	NA	NA	NA	NA	NA
07-1692-P	1000	3/28/2007	Panel #14-E	TNTC	1/8	5/8	NA	NA	NA	NA	NA
07-1693-P	1000	3/28/2007	Panel #14-F	TNTC	1/16	1/2	NA	NA	NA	NA	NA
07-1694-P	1000	3/28/2007	Panel #14-G	TNTC	1/16	5/8	NA	NA	NA	NA	NA
07-1695-P	1000	3/28/2007	Panel #15-E	TNTC	1/32	1/4	NA	NA	NA	NA	NA
07-1696-P	1000	3/28/2007	Panel #15-F	TNTC	1/16	11/32	NA	NA	NA	NA	NA
07-1697-P	1000	3/28/2007	Panel #15-G	TNTC	1/16	1/4	NA	NA	NA	NA	NA

† Table 1: Rating of Failure (From ASTM D 1654)

Scribe Rating			Unscribe Rating
Millimeters	Inches	Rating No.	Area Failed, %
Zero	0	10	No Failure
Over 0 to 0.5	0 to 1/64	9	0 to 1
Over 0.5 to 1.0	1/64 to 1/32	8	2 to 3
Over 1.0 to 2.0	1/32 to 1/16	7	4 to 6
Over 2.0 to 3.0	1/16 to 1/8	6	7 to 10
Over 3.0 to 5.0	1/8 to 3/16	5	11 to 20
Over 5.0 to 7.0	3/16 to 1/4	4	21 to 30
Over 7.0 to 10.0	1/4 to 3/8	3	31 to 40
Over 10.0 to 13.0	3/8 to 1/2	2	41 to 55
Over 13.0 to 16.0	1/2 to 5/8	1	56 to 75
Over 16.0	5/8 +	0	Over 75

* Table 2: Description of Corrosion Codes

NL	No Loss of adhesion (blistering)
NN	No Noticeable adhesion loss (blistering) during exposure period
NA	Not Applicable
NC	No Corrosion
NRR	No Red Rust
+	Exceeding Maximum Allowable Spot Diameter
WCP	White Corrosion Products
BCP	Black Corrosion Products
GCP	Green Corrosion Products
RCP	Red Corrosion Products
RR	Red Rust
TNTC	Too Numerous To Count

Reviewed By: | Date:

Table 73. NASA Outgassing Raw Data

Material / ID	DWR 404732 (Blevins) Lord 201/17 and DWR 404740 Patterson		
Program	Date Tested: 12/7/2006	CCN:	Creed CCN 8WG267E1
Remarks:			Patterson SPC34113

Tube #	VCM / Sample	Haze	TML / WVR	Remarks
	Visual Inspection for Haze: (glass tube) 0 sample + tube 0 tube 0.000000 sample wgt. (g) Haze visible??:		0 sample + tube (prior) Sample + tube (post) 0.000000 Wgt. Loss (g) WVR weight after 24 hours.	#DIV/0! TML (%) #DIV/0! WVR (%)
1 Creed Lord 201/17 CCN 8WG267E1	0 Weight of Tube + sample 0 original wgt. Of Tube 0.118747 weight of sample 1.066286 Weight VCM tube after test 1.066265 Original wgt. VCM tube 0.000021 VCM weight (g) 0.02 % VCM	HAZE	0.118747 Wgt. Tube + Sample (prior test) 0.114068 Wgt. Tube + Sample (post test) 0.004679 Wgt. Loss (g) 3.94 % TML 0.114662 WVR wgt. After 24 hr in 50% RH 0.50 % WVR	green (initial) to brown (post test)
2 Patterson Coupon B1	0 Weight of Tube + sample 0 original wgt. Of Tube 0.228510 weight of sample 1.058479 Weight VCM tube after test 1.057272 Original wgt. VCM tube 0.001207 VCM weight (g) 0.53 % VCM	BAD HAZE	0.42428 Wgt. Tube + Sample (prior test) 0.4217 Wgt. Tube + Sample (post test) 0.002580 Wgt. Loss (g) 1.13 % TML WVR wgt. After 24 hr in 50% RH ~~-184.54 % WVR~~ Not Performed (See Note)	Note Cancel all WVR analysis due to high VCM and hazing
3 Patterson Copuon B6	Weight of Tube + sample original wgt. Of Tube 0.121680 weight of sample 1.070426 Weight VCM tube after test 1.069619 Original wgt. VCM tube 0.000807 VCM weight (g) 0.66 % VCM	Haze	0.31025 Wgt. Tube + Sample (prior test) 0.30903 Wgt. Tube + Sample (post test) 0.001220 Wgt. Loss (g) 1.00 % TML WVR wgt. After 24 hr in 50% RH ~~-253.97 % WVR~~ Not Performed	
Summary	Avg. %VCM		Avg. %TML Avg. %WVR	

Material / ID	Patterson DWR 404740				
Program		Date Tested:	12/7/2006	CCN:	SPC34113
Remarks:					

Tube #

Visual Inspection for Haze: (glass tube)

sample + tube
tube
0.000000 sample wgt. (g)

0 sample + tube (prior)
Sample + tube (post)
0.000000 Wgt. Loss (g)

#DIV/0! TML (%)

Haze visible??:

WVR weight after 24 hours. #DIV/0! WVR (%)

Tube # 5

Patterson Coupon B4

Weight of Tube + sample
original wgt. Of Tube
0.265300 weight of sample

1.053015 Weight VCM tube after test
1.051677 Original wgt. VCM tube
0.001338 VCM weight (g)

0.50 % VCM

HAZE

0.46151 Wgt. Tube + Sample (prior test)
0.45795 Wgt. Tube + Sample (post test)
0.003560 Wgt. Loss (g)

1.34 % TML

WVR wgt. After 24 hr in 50% RH

~~-172.62 % WVR~~ Not Performed

Tube # 6

Patterson Coupon B2

Weight of Tube + sample
original wgt. Of Tube
0.157170 weight of sample

1.055338 Weight VCM tube after test
1.054252 Original wgt. VCM tube
0.001086 VCM weight (g)

0.69 % VCM

HAZE

0.35393 Wgt. Tube + Sample (prior test)
0.35216 Wgt. Tube + Sample (post test)
0.001770 Wgt. Loss (g)

1.13 % TML

WVR wgt. After 24 hr in 50% RH

~~-224.06 % WVR~~ Not Performed

Tube # 7

Patterson Coupon B5

Weight of Tube + sample
original wgt. Of Tube
0.143430 weight of sample

1.061545 Weight VCM tube after test
1.060548 Original wgt. VCM tube
0.000997 VCM weight (g)

0.70 % VCM

HAZE

0.33513 Wgt. Tube + Sample (prior test)
0.33322 Wgt. Tube + Sample (post test)
0.001910 Wgt. Loss (g)

1.33 % TML

WVR wgt. After 24 hr in 50% RH

~~-232.32 % WVR~~ Not Performed

Summary

Avg. %VCM Avg. %TML Avg. %WVR

Material / ID	Patterson DWR 404740				
Program		Date Tested:		CCN:	
Remarks:					

Tube #

Visual Inspection for Haze: (glass tube)

sample + tube
tube
0.000000 sample wgt. (g)

0 sample + tube (prior)
Sample + tube (post)
0.000000 Wgt. Loss (g)

#DIV/0! TML (%)

Haze visible??:

WVR weight after 24 hours. #DIV/0! WVR (%)

Tube # 9

Patterson Coupon B7

Weight of Tube + sample
original wgt. Of Tube
0.312700 weight of sample

1.059417 Weight VCM tube after test
1.058472 Original wgt. VCM tube
0.000945 VCM weight (g)

0.30 % VCM

HAZE

0.50863 Wgt. Tube + Sample (prior test)
0.5053 Wgt. Tube + Sample (post test)
0.003330 Wgt. Loss (g)

1.06 % TML

WVR wgt. After 24 hr in 50% RH

~~-161.59 % WVR~~ Not Performed

Tube # 10

Patterson Coupon B8

Weight of Tube + sample
original wgt. Of Tube
0.244720 weight of sample

1.059547 Weight VCM tube after test
1.058387 Original wgt. VCM tube
0.001160 VCM weight (g)

0.47 % VCM

BAD HAZE

0.44137 Wgt. Tube + Sample (prior test)
0.43839 Wgt. Tube + Sample (post test)
0.002980 Wgt. Loss (g)

1.22 % TML

WVR wgt. After 24 hr in 50% RH

~~-179.14 % WVR~~ Not performed

Tube # 11

Patterson Coupon B3

Weight of Tube + sample
original wgt. Of Tube
0.121960 weight of sample

1.055774 Weight VCM tube after test
1.054852 Original wgt. VCM tube
0.000922 VCM weight (g)

0.76 % VCM

HAZE

0.31529 Wgt. Tube + Sample (prior test)
0.31371 Wgt. Tube + Sample (post test)
0.001580 Wgt. Loss (g)

1.30 % TML

WVR wgt. After 24 hr in 50% RH

~~-257.22 % WVR~~ Not Performed.

Summary

Avg. %VCM Avg. %TML Avg. %WVR

Material / ID	BLANKS				
Program		Date Tested:	12/7/2006	CCN:	
Remarks:					

Tube #

Visual Inspection for Haze: (glass tube)

	sample + tube	0	sample + tube (prior)	#DIV/0!	TML (%)
	tube		Sample + tube (post)		
0.000000	sample wgt. (g)	0.000000	Wgt. Loss (g)		

Haze visible??:

WVR weight after 24 hours. #DIV/0! WVR (%)

Tube # 4

Blank

0	Weight of Tube + sample	0	Wgt. Tube + Sample (prior test)
0	original wgt. Of Tube	0	Wgt. Tube + Sample (post test)
0.000000	weight of sample	0.000000	Wgt. Loss (g)
		#DIV/0!	% TML
1.0527	Weight VCM tube after test		
1.052691	Original wgt. VCM tube		
0.000009	VCM weight (g)		WVR wgt. After 24 hr in 50% RH
#DIV/0!	% VCM	#DIV/0!	% WVR

Tube # 8

Blank

0	Weight of Tube + sample	0	Wgt. Tube + Sample (prior test)
0	original wgt. Of Tube	0	Wgt. Tube + Sample (post test)
0.000000	weight of sample	0.000000	Wgt. Loss (g)
		#DIV/0!	% TML
1.061461	Weight VCM tube after test		
1.061428	Original wgt. VCM tube		
0.000033	VCM weight (g)		WVR wgt. After 24 hr in 50% RH
#DIV/0!	% VCM	#DIV/0!	% WVR

Tube #

	Weight of Tube + sample	0	Wgt. Tube + Sample (prior test)
	original wgt. Of Tube		Wgt. Tube + Sample (post test)
0.000000	weight of sample	0.000000	Wgt. Loss (g)
		#DIV/0!	% TML
	Weight VCM tube after test		
	Original wgt. VCM tube		
0.000000	VCM weight (g)		WVR wgt. After 24 hr in 50% RH
#DIV/0!	% VCM	#DIV/0!	% WVR

Summary

Avg. %VCM Avg. %TML Avg. %WVR

Table 74. Fluids Resistance Raw Data

ISSC-JAX C/4.9.7.6
LTPC Data Summary

Test	Coating System	Alloy	Result	Baseline Criteria
Dry Adhesion	TGIC	2024-T3	5	P
		2024-T3 (No CC)	5	P
		2024-T3 Clad	5	P
		2024-T3 Clad (No CC)	5	P
		7075-T6	5	P
		7075-T6 (No CC)	5	P
		6061-T6	5	P
		6061-T6 (No CC)	5	P
		AISI 4130	5	P

Test	Coating System	Alloy	Result	Baseline Criteria
Wet Adhesion 1 Day	TGIC	2024-T3	5, 4.5	P
		2024-T3 (No CC)	0.1	F
		2024-T3 Clad	5, 4.5	P
		2024-T3 Clad (No CC)	5	P
		7075-T6	5	P
		7075-T6 (No CC)	2, 1	F
		6061-T6	4.5	P
		6061-T6 (No CC)	0.1	F
		AISI 4130	0.1	F

Test	Coating System	Alloy	Result	Baseline Criteria
Wet Adhesion 4 Day	TGIC	2024-T3	5	P
		2024-T3 (No CC)	5	P
		2024-T3 Clad	5	P
		2024-T3 Clad (No CC)	5	P
		7075-T6	5	P
		7075-T6 (No CC)	5	P
		6061-T6	4.5, 5	P
		6061-T6 (No CC)	5	P
	Note: Baseline 5,3	AISI 4130	0.1	F

Test	Coating System	Alloy	Result	Baseline Criteria
Wet Adhesion 7 Day	TGIC	2024-T3	5	P
		2024-T3 (No CC)	5	P
		2024-T3 Clad	5	P
		2024-T3 Clad (No CC)	5	P
		7075-T6	5	P
		7075-T6 (No CC)	5	P
		6061-T6	5	P
		6061-T6 (No CC)	5	P
		AISI 4130	5	P

Test	Coating System	Alloy	Result	Baseline Criteria
Solvent Resistance	TGIC	2024-T3	Pass	P
				Some Softening

ISSC-JAX C/4.9.7.6
LTPC Data Summary

Test	Coating System	Alloy	Result	Baseline Criteria
Fluid Resistance	TGIC	2024-T3	Pass	P
				MIL-PRF-83282

Test	Coating System	Alloy	Result	Baseline Criteria
Fluid Resistance	TGIC	2024-T3	Pass	P
				JP-5

Test	Coating System	Alloy	Result	Baseline Criteria
Topcoat Compatability	TGIC	7075-T6	Pass	P

Test	Coating System	Alloy	Result	Baseline Criteria
Stripability	TGIC	2024-T3	Pass	P

Test	Coating System	Alloy	Result	Baseline Criteria
Flexibility	TGIC	2024-T3	10%	F

Test	Coating System	Alloy	Result	Baseline Criteria
B117	TGIC	In Test		

Test	Coating System	Alloy	Result	Baseline Criteria
Filiform	TGIC	In Test		

Test	Coating System	Alloy	Result	Baseline Criteria
SO2	TGIC	In Test		

Table 75. Chipping Resistance Raw Data

Initial Gravelometer Test

SAE J400 Method C with 2" Tape Used to Remove Chips

Panel Coating/Panel #	Damaged Area, %	Chip Rating
Powder Coat, 102	0.61	2A-5B-10C-10D
Powder Coat, 104	0.56	2A-6B-10C-10D
Powder Coat, 108	0.74	2A-5B-10C-10D
Powder Coat, 114	0.71	1A-5B-10C-10D
	Avg: 0.655	
Liquid Coating, 127	1.15	1A-4B-10C-10D
Liquid Coating, 128	1.04	1A-5B-10C-10D
Liquid Coating, 129	1.42	1A-4B-10C-10D
Liquid Coating, 130	1.28	1A-4B-10C-10D
	Avg: 1.222	

Gravelometer Test After 7 Days Immersion in JP-5 at Room Temperature

SAE J400 Method C with 2" Tape Used to Remove Chips

Panel Coating/Panel #	Damaged Area, %	Chip Rating
Powder Coat, 116	0.55	1A-6B-10C-10D
Powder Coat, 117	0.40	3A-6B-10C-10D
Powder Coat, 118	0.40	2A-6B-10C-10D
	Avg: 0.45	
Liquid Coating, 149	1.32	1A-4B-10C-10D
Liquid Coating, 152	1.16	1A-5B-10C-10D
Liquid Coating, 153	1.11	2A-5B-10C-10D
	Avg: 1.20	

Example:
Panel #102

2A	100 -149 Chips	< 1 mm
5B	25-49 Chips	1-3 mm
10C	0 - Chips	3-6 mm
10D	0 - Chips	> 6 mm

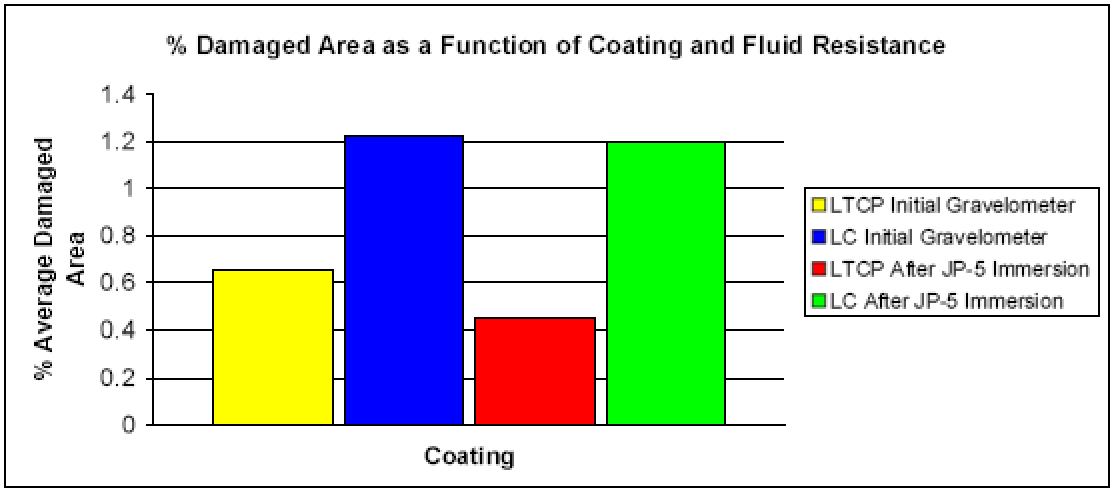
TABLE 1—NUMBER CATEGORIES FOR CHIP RATING

Rating Number	Number of Chips	Rating Number	Number of Chips
10	0	4	50–74
9	1	3	75–99
8	2–4	2	100–149
7	5–9	1	150–250
6	10–24	0	>250
5	25–49		

TABLE 2—SIZE CATEGORIES FOR CHIP RATING

Rating Letter	Size of Chips
A	< 1 mm (>approximately 0.03 in)
B	1–3 mm (approximately 0.03–0.12 in)
C	3–6 mm (approximately 0.12–0.25 in)
D	>6 mm (>approximately 0.25 in)

	Initial		Post JP-5	
	LTCP Damage	LC Damage	LTCP Damage	LC Damage
	0.61	1.15	0.55	1.32
	0.56	1.04	0.4	1.16
	0.74	1.42	0.4	1.11
	0.71	1.28		
Avg	0.655	1.2225	0.45	1.20



APPENDIX E: FLUID RESISTANCE AND IMPACT/CHIPPING RESISTANCE

1.0 LTCPC Supplemental Data

In addition to the initial JTP tests, LTCPC team members determined that a few additional performance areas should be quantified. Among these areas were fluid resistance, and impact/chipping resistance. The LTCPC team became aware that fluid resistance and impact/chipping resistance evaluations had been performed under a separate study by the Navy. Rather than duplicate testing, the LTCPC team requested that data; the data is also included in the final report for that project [9].

2.0 Test Procedures

2.1 Fluids Resistance

<u>Test Preparation</u>

Coupons for fluids resistance testing shall follow the preparation and application procedures previously outlined in Section 5.1.2.2.1. The only deviation from JTP methods is the omission of preparing and testing three coupons without a chromate conversion coating for each fluid.

<u>Test Procedures</u>

Subject three coupons with a chromate conversion coating to each of the following three fluids identified by MIL-PRF-85285D.

- MIL-L-23699 Lubricating Oil
- MIL-PRF-83282 Hydraulic Fluid
- JP-5 Fuel (conforming to MIL-DTL-5624)

The coating applied to test coupons shall be immersed in the fluids, at the temperatures and minimum times specified in Section 4.6.8 of MIL-PRF-85285D. The coating film shall be examined one hour after removal from the fluid for conformance. The coating shall not exhibit any blistering, softening, or other coating defects after immersion. However slight staining of the coating is acceptable.

Table 76. Fluids Resistance Test Methodology

Parameters	Lubricating Oil: Soak specimen in fluid at 250 ± 5 °F for ≥ 24 hours Hydraulic Fluid: Soak specimen in fluid at 150 ± 5 °F for ≥ 24 hours JP-5 Fuel: Soak specimen in fluid at RT for ≥ 7 days - Examine coatings one hour after removal
Coupons Per Coating System	Nine coupons: Al-2 (3 per fluid) LTCPC
Trials Per Coupon	One
Control Coupons Required	None
Acceptance Criteria	After immersion the coating shall exhibit no blistering, softening, or other coating defects. Slight staining of the coating is acceptable.

Major or Unique Equipment

- None

Data Analysis and Reporting

- Photograph and report the condition of the coated surface after each fluid immersion, noting the appearance of any failure modes

Testing Organization and Location

- CTC Environmental Technology Facility, Johnstown, PA

2.2 Chipping Resistance

Description and Rationale

This test relates to the ability of a coating system to minimize or altogether avoid surface chipping that results from small-diameter foreign object impacts. Impacts of this nature are commonly encountered by aircraft with the capability to land on semi-improved and/or unimproved aircraft runways. Chipping resistance testing shall be run per procedures outlined within ASTM D 3170; *Standard Test Method for Chipping Resistance of Coating*.

Test Preparation

LTCPC coupons for chipping resistance testing shall follow the preparation and application procedures previously outlined in Section 5.1.2.2.2 while control coupons shall follow those procedures found in Section 5.1.2.3.3. Gravel used during the testing shall be water-eroded alluvial road gravel that passes through a 5/8 inch space screen but is retained on a 3/8 inch space screen.

Test Procedures

The LTCPC and control specimens shall be subjected to chipping resistance testing “as is” using a modular-style gravelometer test apparatus.

Chipping resistance shall be determined using the standard number-letter rating approach, in which numbers (ten through zero) indicate the number of chips and letters (A through D) designate the size of corresponding chips. Both the number and letter chip rating scales are located within the Visual Comparison Procedure section of ASTM D 3170.

Table 77. Chipping Resistance Test Methodology

Parameters	Gravelometer: Air pressure = 70 ± 3 psi with valve open Gravel volume ≈ one pint Full gravel expulsion within 7 – 10 seconds All Specimens: Condition test panels at RT for one hour Remove any loose/damaged paint with No. 898 filament strapping tape
Coupons Per Coating System	Three coupons: Al-2 LTCPC
Trials Per Coupon	One
Control Coupons Required	Three
Acceptance Criteria	LTCPC exhibits chipping resistance that equals or exceeds the rating determined for the baseline coating system.

Major or Unique Equipment

- Cabinet style gravelometer
- Compressed air supply
- Water-eroded alluvial road gravel (3/8 – 5/8 inch diameter range)
- No. 898 filament strapping tape (four inch width)

Data Analysis and Reporting

- Photograph and report on the coated surface’s condition after completing gravel exposure and rate the coating’s performance using the ASTM-derived number and letter system

Testing Organization and Location

- CTC Environmental Technology Facility, Johnstown, PA

3.0 Test Results

3.1 Fluids Resistance

CTC in Johnstown conducted fluids resistance testing of the following substrate/coating system combinations. The LTCPC coupons displayed acceptable resistance to the three operational fluid exposures called out within MIL-PRF-85285D.

Table 78. Fluids Resistance Results

Coating System	Substrate	Pretreatment	Coupon 1	Coupon 2	Coupon 3
Lubricating Oil (conforming to MIL-L-23699)					
LTCPC	2024-T3	CCC*	Pass	Pass	Pass
MIL-P-53022/85285	2024-T3	CCC	Pass	Pass	Pass
Hydraulic Fluid (conforming to MIL-PRF-83282)					
LTCPC	2024-T3	CCC	Pass	Pass	Pass
MIL-P-53022/85285	2024-T3	CCC	Pass	Pass	Pass
JP-5 Fuel (conforming to MIL-DTL-5624)					
LTCPC	2024-T3	CCC	Pass	Pass	Pass
MIL-P-53022/85285	2024-T3	CCC	Pass	Pass	Pass

* Chromate Conversion Coating
(pink) = Unacceptable test result
(yellow) = Marginal test result
(green) = Acceptable test result

Overall fluids resistance test results for LTCPC coupons proved to be acceptable as defined within Section 2.1of this appendix. Each of the prepared aluminum 2024-T3 specimens met the acceptance criteria for resistance to immersion in common operational fluids by exhibiting no signs of blistering, softening, or other coating defects.

Figures 53 through 55 are of the immersion tanks utilized for this evaluation.

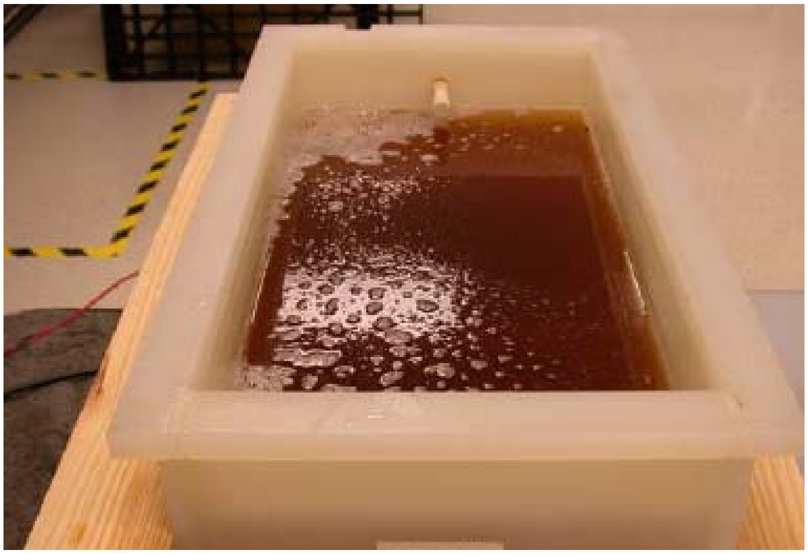


Figure 53. Lubricating Oil Immersion Tank

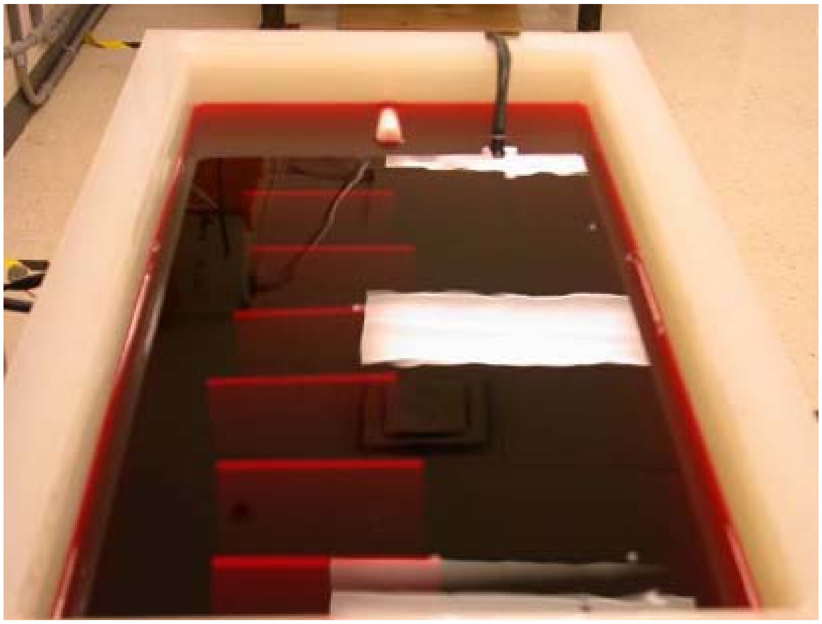


Figure 54. Hydraulic Fluid Immersion Tank

Figure 55. JP-5 Fuel Immersion Tank

3.2 Chipping Resistance

CTC employed a *Q-Panel Model X-9408-X Multi-Test Gravelometer* (modular-style) with water-worn gravel media to determine the chipping resistance of both the baseline coating and LTCPC. According to these procedures a four inch wide filament strapping tape should be used to remove any loose or damaged paint. CTC personnel made a minor modification to this test method by using a roll of filament tape which was only two inches wide. All of the remaining tape characteristics were identical to those required for the referenced four inch wide roll.

Chipping resistance testing occurred for the following substrate/coating system combinations. Based on test procedures all of the coupons provided acceptable resistance to chipping. However, on average the LTCPC coupons received better ratings than the baseline panels.

Table 79. Chipping Resistance Results

Coating System	Substrate	Pretreatment	Coupon 1	Coupon 2	Coupon 3	Coupon 4
			Coupon Surface Area Damage (%)			
LTCPC	2024-T3	CCC*	0.61	0.56	0.74	0.71
MIL-P-53022/85285	2024-T3	CCC	1.15	1.04	1.42	1.28
			Coating Chip Rating (ref. Tables 80 and 81)			
LTCPC	2024-T3	CCC	2A-5B-10C-10D	2A-6B-10C-10D	2A-5B-10C-10D	1A-5B-10C-10D
MIL-P-53022/85285	2024-T3	CCC	1A-4B-10C-10D	1A-5B-10C-10D	1A-4B-10C-10D	1A-4B-10C-10D

* Chromate Conversion Coating
= Unacceptable test result
= Marginal test result
= Acceptable test result

Chip rating letter represents size range and rating number corresponds to quantity of chips within that specific size range (ref. Tables 80 and 81)

Tables 42 and 43 (from ASTM D 3170) outline the number and letter designations of chip ratings.

Table 80. Number (Quantity) Categories for Chip Rating

Rating Number	Number of Chips
10	0
9	1
8	2–4
7	5–9
6	10–24
5	25–49
4	50–74
3	75–99
2	100–149
1	150–250
0	>250

Table 81. Letter (Size) Categories for Chip Rating

Rating Letter	Size of Chips
A	<1 mm (approximately 0.03 in.)
B	1–3 mm (approximately 0.03–0.12 in.)
C	3–6 mm (approximately 0.12–0.25 in.)
D	>6 mm (approximately 0.25 in.)

The use of a gravelometer to determine chipping resistance produced specimen coating damage comparable to the two coupons shown in Figures 56 and 57 under 10X magnification.

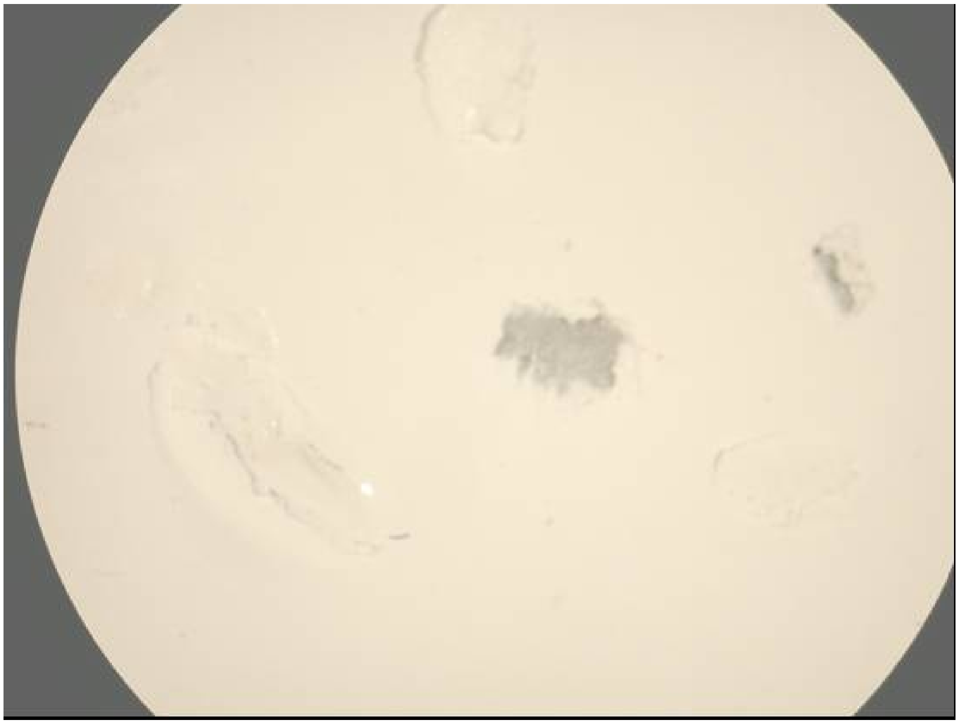


Figure 56. LTCPC Chipping Resistance Test Outcome

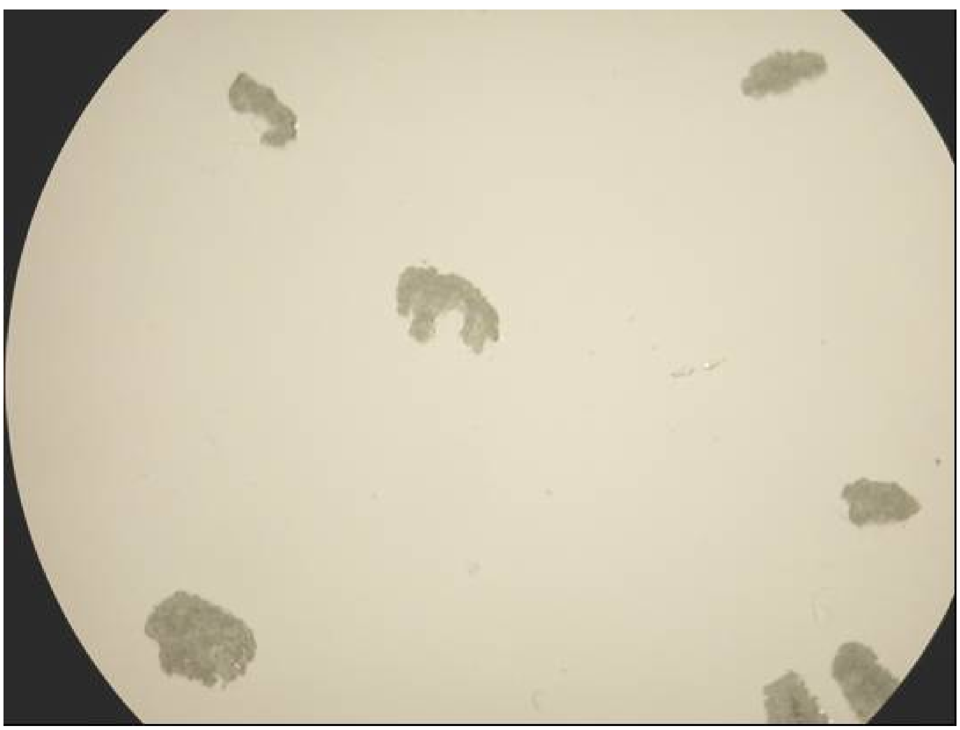


Figure 57. Control Coating Chipping Resistance Test Outcome

Chipping resistance tests confirm that LTCPC performance equals or exceeds the results observed for the selected baseline stack-up. The 2024-T3 LTCPC specimens exhibited lower coating damage than the controls measured as a percentage of the coating's surface. Surface damage percentages measured for the coupons ranged from 0.56 – 0.74%. In comparison the controls permitted between 1.04 – 1.42% of the surface to be damaged by chipping. In addition the LTCPC chip ratings were better than or equal to those reported for the control coupons.

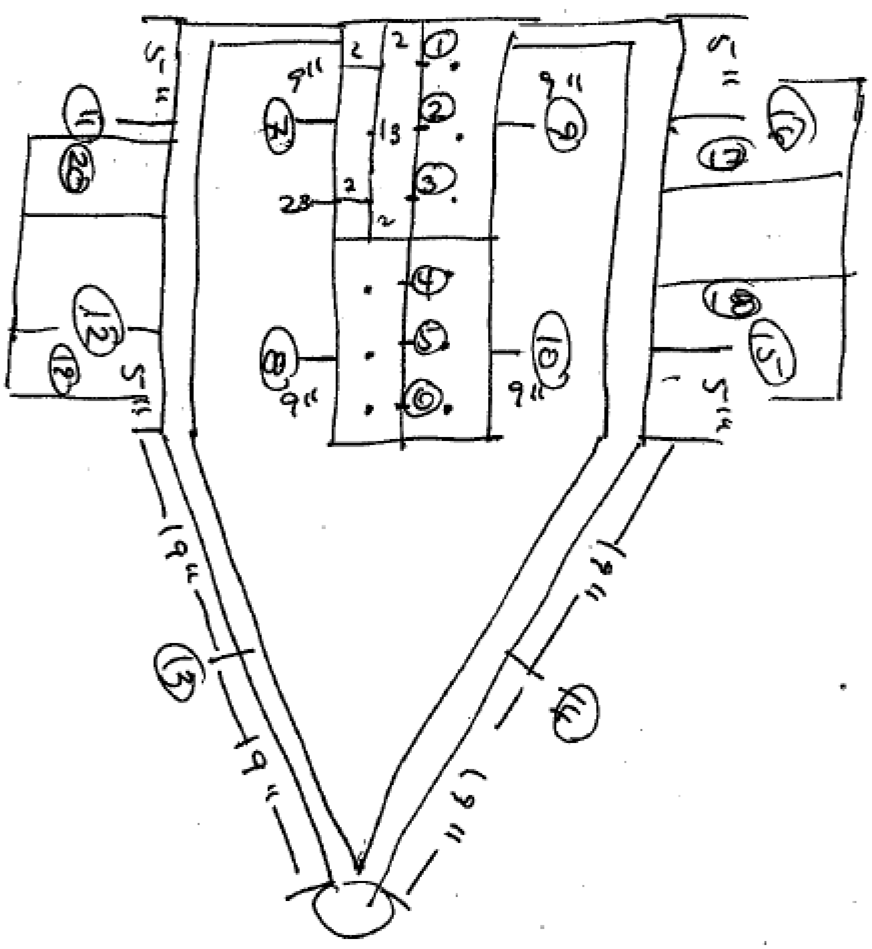
APPENDIX F: FIELD SERVICE EVALUATION RAW DATASHEETS

Table 82. Nitrogen Servicing Cart NRR073 Raw Data

Instructions for Use.

1. At first evaluation, fill out Field Service Evaluation Checklist #1 to include the time in terms of process time (how long was component in the paint shop), actual labor hours while part was being coated, and amount of powder used (estimated).

2. Before taking measurements for Field Service Evaluation Checklist #2, obtain a drawing, create a hand drawing, or take measurements from a common datum point to the points on the component where the test measurements will/are made. This drawing or other documentation should remain with both of these checklists so that it is available for follow on sampling.



Field Service Evaluation Checklist #1

Component ID: GJFM, P/N 1317AS100 -2

Component Name: NAN Cart.

Serial Number: NRR073

Date of Inspection: 3/6/08

Name of Inspector: Steve Finley

Location of Inspection: USS Reagan CVN 76

Time of Inspection: 0930

Part arrival in Paint Shop, Date, Time: ____

Earliest Date, Time when part could depart: ____

Preheat time (if any): ____ minutes

Time to apply powder on component: ____ minutes

Amount of powder applied (pounds): ____

Complete following if doing a two pass coating

1st Bake (if applicable): ____ minutes

Second powder application (if applicable): ____ minutes

Amount of powder in second coat (if applicable)(pounds): ____

Complete the following for all applications

Full bake time: ____ minutes

Time from bake end to de-mask start (cool down time): ____ minutes

Field Service Evaluation Checklist #2

Component ID: GJFN, P/N 1317AS100-2

Component Name: NAN CART

Serial Number: NRR073

Date of Inspection: __________

Name of Inspector: __________

Location of Inspection: __________

Time of Inspection: __________

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	Pinholes evident
Gloss #1	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 71.6 85° 93.3 thk 14.2 mils
Gloss #2	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 75.3 85° 93.0 thk 9.66 mils
Gloss #3	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 71.9 85° 83.5 thk 7.56 mils
Gloss #4	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 70.4 85° 79.8 thk 4.99 mils
Gloss #5	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 63.3 85° 71.6 thk 3.99 mils
Gloss #6	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 52.2 85° 58.1 thk 4.96 mils very rough

NRR073

(7) 60° 51.5
85° 61.2
thk 3.17 mils

(8) 60° 60.3
85° 66.3
thk 4.11 mils

(9) 60° 79.5
85° 83.9
thk 5.14 mils

(10) 60° 54.5
85° 67.7
thk 2.48 mils

(11) 60° 56.1
85° 57.0
thk 7.93

(12) 60° 74.3
85° 76.5
thk 10.4 mils

(13) 60° 61.5
85° 63.1
thk 10.5 mils
} grind marks

(14) 60° 78.0
85° 85.8
thk 14.2 mils

(15) 60° 74.3
85° 74.9
thk 13.6 mils

(16) 60° 59.2
85° 61.2
thk 8.29 mils

(17) 60° 78.8
85° 88.2
thk 8.27 mils

(18) 60° 78.6
85° 82.6
thk 6.94 mils

(19) 60° 59.0
85° 73.7
thk 7.95 mils

(20) 60° 75.2
85° 90.1
thk 6.82 mils

NRR073

Field Service Evaluation Checklist (Continued)

Component ID: G3FM, PN 1317AS160-2
Component Name: NAN CART
Serial Number: NRR073

Performance Criteria	Instructions	Results and Observations
Color #1	Using attached drawing, determine location to take measurement.	L 94.60 A -0.60 #32 B 4.68
Color #2	Using attached drawing, determine location to take measurement.	L 94.81 A -0.50 #33 B 5.06
Color #3	Using attached drawing, determine location to take measurement.	L 95.39 A -0.65 #34 B 4.00
Color #4	Using attached drawing, determine location to take measurement.	L 94.48 A -0.75 #35 B 3.88
Color #5	Using attached drawing, determine location to take measurement.	L 92.94 #36 A -0.83 B 4.10
Color #6	Using attached drawing, determine location to take measurement.	L 94.49 #37 A -0.79 B 3.71
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes: ______

(Add additional pages as necessary)

NRR073

Sample		Value	No.
(7)	L	92.95	
	A	−0.95	#31
	B	3.25	
(8)	L	92.76	
	A	−0.78	#30
	B	3.86	
(9)	L	93.81	
	A	−0.77	#21
	B	4.53	
(10)	L	92.45	
	A	−0.97	#22
	B	3.29	
(11)	L		
	A		
	B		
(12)	L	93.83	
	A	−0.50	#27
	B	5.34	
(13)	L	94.28	
	A	−0.33	#26
	B	5.52	
(14)	L	94.97	
	A	−0.30	#25
	B	5.53	
(15)	L	95.66	
	A	−0.33	#24
	B	4.86	
(16)	L		
	A		
	B		
(17)	L	95.02	
	A	−0.59	#20
	B	4.73	
(18)	L	95.00	
	A	−0.60	#23
	B	4.39	
(19)	L	93.74	
	A	−0.46	#28
	B	5.06	
(20)	L	94.68	
	A	−0.64	#29
	B	4.37	

Field Service Evaluation Checklist

Component ID: GJFM, P/N 1317A5100-2

Component Name: Nitrogen Service Cart

Serial Number: NRR 073

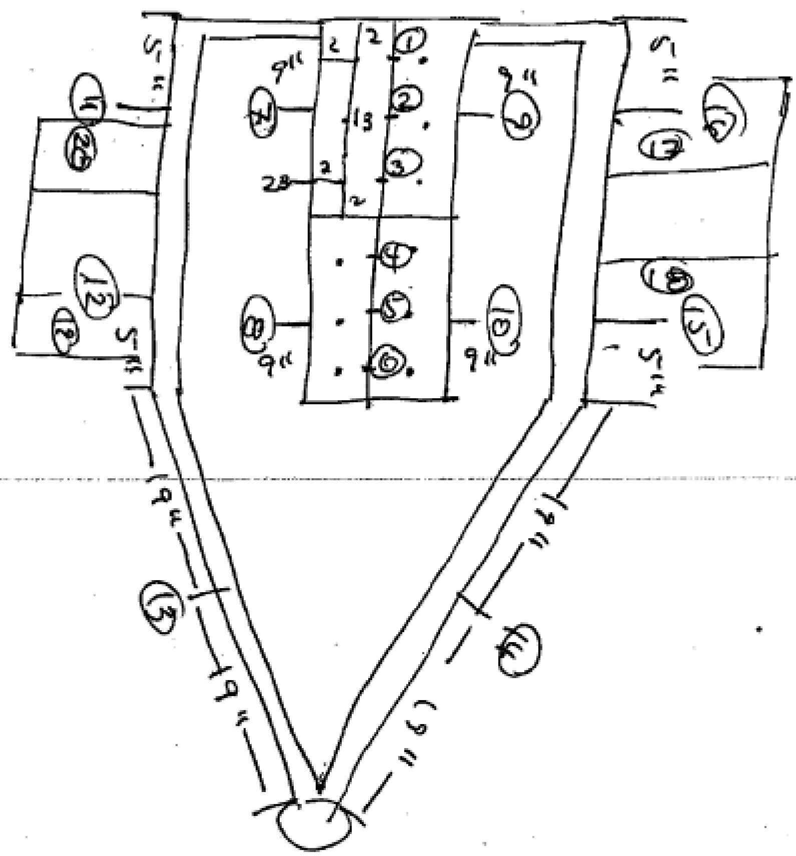
Date of Inspection: 3 February 2009

Reason For Inspection: Second Field Evaluation

Name of Inspector: ____________________

Location of Inspection: USS Ronald Reagan CVN 76

Time of Inspection: 0945



All surfaces to be measured were wiped clean.

Reading	Data	Comments
1	60° 72.2 L* 92.44 85° 77.5 a* 8.21 DFT 9.53 b* -0.16 Trial 2	
2	60° 74.2 L* 91.18 85° 84.0 a* -0.26 DFT 8.32 b* 8.18 Trial 3	
3	60° 52.9 L* 89.54 85° 57.3 a* -0.35 DFT 5.55 b* 7.70 Trial 4	highly scratched
4	60° 53.9 L* 87.82 85° 73.3 a* -0.25 DFT 4.11 b* 7.99 Trial 5	" "
5	60° 28.9 L* 88.34 85° 39.0 a* -0.44 DFT 4.07 b* 7.57 Trial 6	highly scratched, orange peel
6	60° 55.9 L* 89.87 85° 60.9 a* -0.43 DFT 4.66 b* 7.22 Trial 7	" "

7	60° 56.9 85° 67.1 DFT 3.35	L* 91.12 a* -0.59 b* 5.25 Trial 8	
8	60° 53.5 85° 63.4 DFT 2.85	L* 89.99 a* -0.72 b* 4.86 Trial 9	
9	60° 69.2 85° 85.2 DFT 5.22	L* 92.60 a* -0.73 b* 5.90 Trial 10	
10	60° 70.8 85° 83.9 DFT 3.70	L* 91.24 a* -0.53 b* 5.95 Trial 11	
11	60° 68.3 85° 80.0 DFT 7.26	L* a* b* Trial	
12	60° 63.1 85° 82.6 DFT 7.91	L* ~~91.24~~ 90.01 a* ~~[illegible]~~ -0.09 b* ~~[illegible]~~ 6.66 Trial 12	
13	60° 52.0 85° 62.8 DFT 11.0	L* 92.70 a* -0.28 b* 7.01 Trial 13	

14	60° 66.6 85° 81.9 DFT ~~20.1~~ 18.2	L* 92.92 a* -0.16 b* 7.24 Trial 14	
15	60° 63.8 85° 67.5 DFT 13.0	L* 92.66 a* -0.13 b* 6.34 Trial 15	
16	60° 39.5 85° 56.7 DFT 9.84	L* a* b* Trial	
17	60° 67.8 85° 94.7 DFT 11.1	L* 90.20 a* -0.04 b* 6.68 Trial 16	
18	60° 59.3 85° 82.5 DFT 8.50	L* 89.37 a* -0.08 b* 7.12 Trial 17	
19	60° 61.5 85° 87.3 DFT 6.46	L* 90.09 a* -0.15 b* 6.35 Trial 18	
20	60° 48.6 85° 66.4 DFT 4.34	L* 89.36 a* -0.25 b* 6.97 Trial 19	

Field Service Evaluation Checklist

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes: Deep scratches on all surfaces. Holding up well. No additional problems in orange peel areas. Nitrogen bottles showing corrosion in abraded areas. Straps corroding due to welding slag in rough areas. On straight areas, there is no undercutting! Light corrosion on top surface between opening panels due to orange peel and/or insufficient coating.

(Add additional pages as necessary)

Field Service Evaluation Checklist

Component ID: GJFM, P/N 1317A5100-2

Component Name: Nitrogen Service Cart

Serial Number: NRR 073

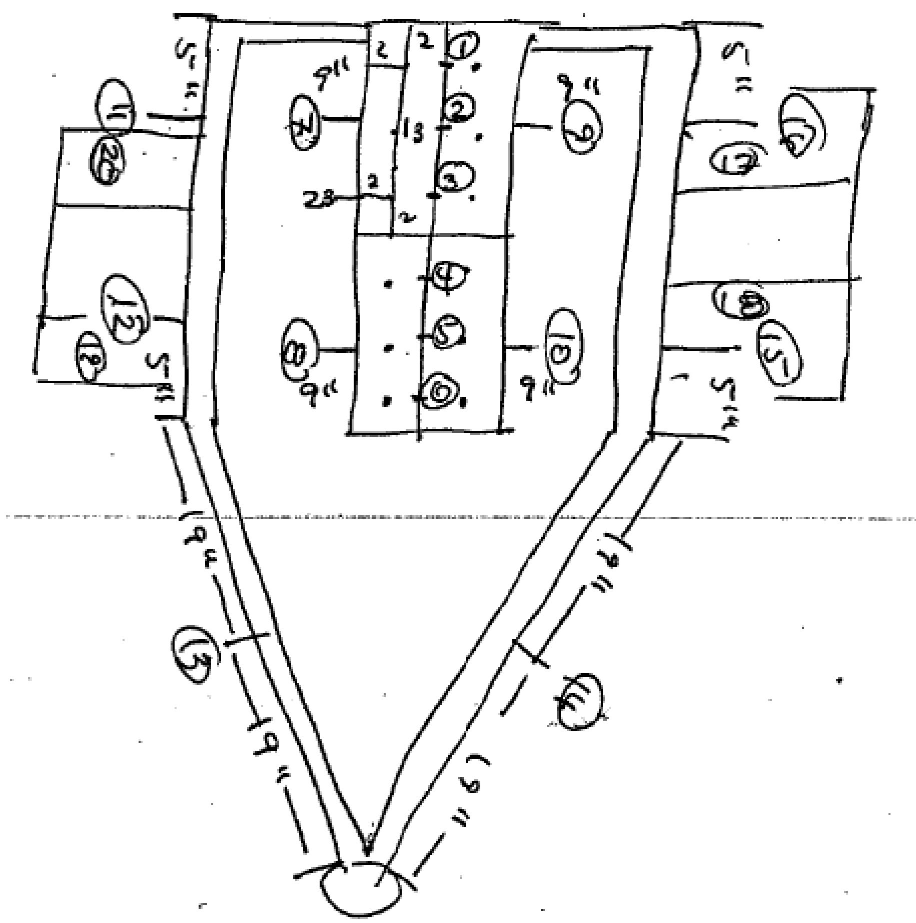
Date of Inspection: 4 November 2009

Reason For Inspection: Third Field Evaluation

Name of Inspector: Steve Finley

Location of Inspection: USS Ronald Reagan CVN 76

Time of Inspection: 10.45



Reading	Data	Comments
1	60° 62.8 L* 92.21 85° 78.8 a* -0.22 DFT 12.3 b* 9.14 Trial Ø3	
2	60° 63.2 L* 88.29 85° 81.9 a* 0.30 DFT 7.76 b* 11.13 Trial Ø4	
3	60° 32.1 L* 86.01 85° 70.2 a* 0.50 DFT 7.76 b* 13.85 Trial Ø5	Shifting away from surface corrosion area.
4	60° 24.8 L* 87.42 85° 45.7 a* 0.15 DFT 5.24 b* 11.77 Trial Ø6	" " " Discoloration and surface rust where reading taken.
5	60° L* 85° a* DFT b* Trial	No reading possible
6	60° L* 85° a* DFT b* Trial	"

7	60° 43.4	L* 87.82	shifting due to surface corrosion,
	85° 51.7	a* 0.06	
	DFT 5.83	b* 11.40	
		Trial Ø7	
8	60° 14.2	L* 74.33	
	85° 38.4	a* 0.21	
	DFT 4.46	b* 9.54	
		Trial Ø8	
9	60° 51.9	L* 88.70	
	85° 74.9	a* 0.00	
	DFT 5.60	b* 10.27	
		Trial Ø9	
10	60° 26.7	L* 87.62	Shift measurement due to surface corrosion
	85° 48.0	a* 0.16	
	DFT 5.49	b* 10.98	
		Trial 10	
11	60° 17.2	L*	No reading possible
	85° 29.0	a*	
	DFT 6.89	b*	
		Trial	
12	60° 26.2	L* ~~87.62~~ 85.87	
	85° 37.4	a* 0.47	
	DFT 8.73	b* 9.06	
		Trial 11	
13	60° 33.1	L* 88.16	
	85° 39.4	a* 0.23	
	DFT 9.72	b* 9.73	
		Trial 12	

14	60° 36.4 L* 87.62 85° 58.0 a* 0.49 DFT 16.9 b* 10.59 Trial 13	
15	60° 38.8 L* 91.51 85° 55.9 a* 0.05 DFT 14.8 b* 6.72 Trial 14	
16	60° 33.3 L* 85° 51.4 a* DFT 9.13 b* Trial	No reading possible.
17	60° 52.3 L* 92.42 85° 87.6 a* -0.09 DFT 11.4 b* 7.16 Trial 15	
18	60° 50.2 L* 91.39 85° 87.2 a* -0.07 DFT 10.2 b* 6.83 Trial 16	
19	60° 56.2 L* 88.95 85° 78.6 a* 0.12 DFT 8.40 b* 8.36 Trial 17	
20	60° 28.7 L* 85° 65.3 a* DFT 6.42 b* Trial	No reading possible.

Field Service Evaluation Checklist

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes: Lots of surface rust everywhere. Bottles in pretty good shape.

(Add additional pages as necessary)

MONTHLY EVALUATION OF COATED COMPONENT LOG

Component Serial No. NRR073
Evaluating Activity USS RONALD REAGAN CVN-76

Date of Inspection 04 NOV 08

	Yes	No
Is the component completely coated?	X	
Is the component free from corrosion?	X	
Overall, is the coating system holding up well?	X	
Is the component free from chipping?	X	
Is the component free from flaking or peeling?	X	
Is the coating free from discoloration?	X	

Comments and observations: UNIT HAS A LITTLE CORROSION ON THE BOXES, AROUND THE HINGES MINOR CORROSION. PAINT IS HOLDING UP WELL .

MONTHLY EVALUATION OF COATED COMPONENT LOG

Component Serial No. NRR073
Evaluating Activity USS RONALD REAGAN CVN-76

Date of Inspection 06 JAN 09

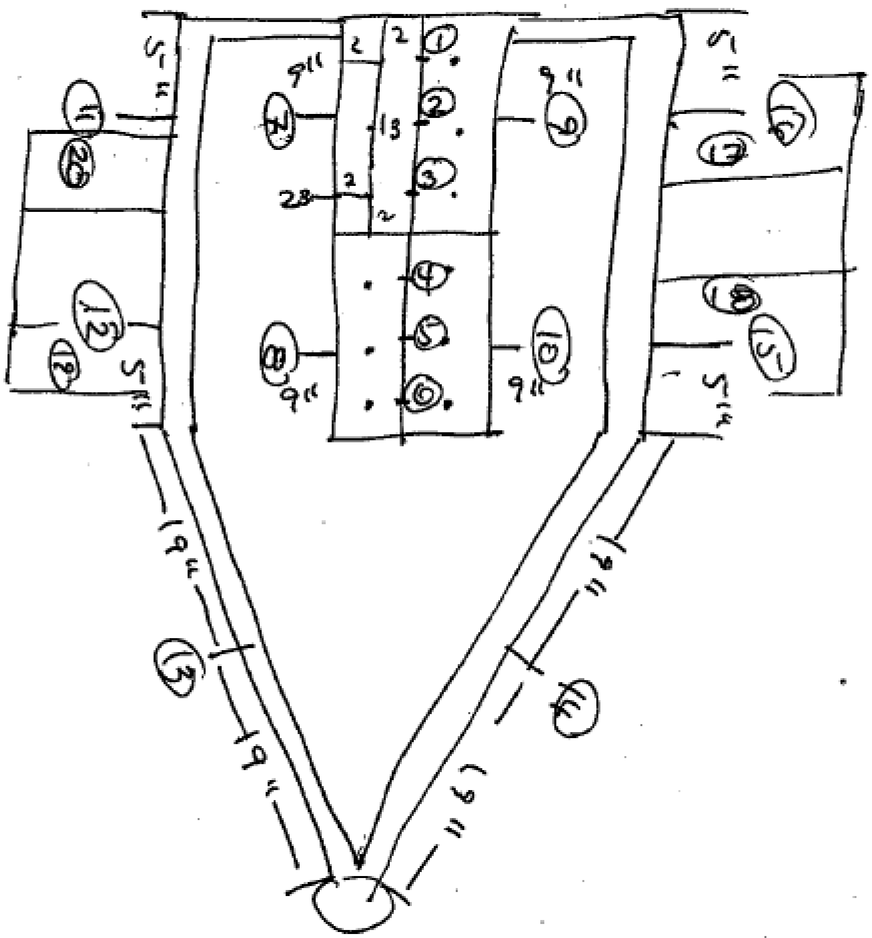
	Yes	No
Is the component completely coated?	X	
Is the component free from corrosion?	X	
Overall, is the coating system holding up well?	X	
Is the component free from chipping?	X	
Is the component free from flaking or peeling?	X	
Is the coating free from discoloration?	X	

Comments and observations: UNIT HAS A LITTLE CORROSION ON THE BOXES, AROUND THE HINGES MINOR CORROSION. PAINT IS HOLDING UP WELL .

Table 83. Nitrogen Servicing Cart NRR204 Raw Data

Instructions for Use.

1. At first evaluation, fill out Field Service Evaluation Checklist #1 to include the time in terms of process time (how long was component in the paint shop), actual labor hours while part was being coated, and amount of powder used (estimated).
2. Before taking measurements for Field Service Evaluation Checklist #2, obtain a drawing, create a hand drawing, or take measurements from a common datum point to the points on the component where the test measurements will/are made. This drawing or other documentation should remain with both of these checklists so that it is available for follow on sampling.



Field Service Evaluation Checklist #1

Component ID: ~~H~~ GJFM, P/N 1317AS100-2

Component Name: NAN Cart

Serial Number: NRR204

Date of Inspection: 3/6/08

Name of Inspector: Steve Finley

Location of Inspection: USS Reagan CVN 76

Time of Inspection: 0945

Part arrival in Paint Shop, Date, Time:________

Earliest Date, Time when part could depart:________

Preheat time (if any):________ minutes

Time to apply powder on component:________ minutes

Amount of powder applied (pounds):________

Complete following if doing a two pass coating

1st Bake (if applicable):________ minutes

Second powder application (if applicable):________ minutes

Amount of powder in second coat (if applicable)(pounds):________

Complete the following for all applications

Full bake time:________ minutes

Time from bake end to de-mask start (cool down time):________ minutes

Field Service Evaluation Checklist #2

Component ID: ~~NRR 204~~ GSFM, P/N 1317AS100-2
Component Name: NAN CART
Serial Number: NRR 204

Date of Inspection: ____
Name of Inspector: SF
Location of Inspection: CVN 76
Time of Inspection: 0945

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Gloss #1	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 68.6 85° 75.4 6.56 mils
Gloss #2	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 80.3 85° 88.8 thk 5.47 mils
Gloss #3	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 75.9 85° 86.4 thk 6.22 mils
Gloss #4	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 65.0 85° 81.3 thk 5.80 mils
Gloss #5	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 71.6 85° 86.1 thk 5.18 mils
Gloss #6	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 69.2 85° 87.2 thk 10.4 mils

#7 60° 64.4
85° 70.1
thk 7.02 mils

#8 60° 69.4
85° 80.7
thk 5.56 mils

#9 60° 66.5
85° 81.6
thk 9.88 mils

#10 60° 63.2
85° 84.0
thk 7.57 mils

#11 60° 63.3
85° 65.4
thk 11.4 mils

#12 60° 59.2
85° 76.5
thk 9.15 mil

#13 60° 54.5
85° 64.4
thk 6.94 mils

#14 60° 52.2
85° 61.5
thk 6.01

#15 60° 62.0
85° 76.4
thk 10.1 mils

#16 60° 55.7
85° 79.1
thk 9.09

#17 60° 65.2 NRR204
85° 69.0
thk 7.72 mils

#18 60° 71.7
85° 89.7
thk 9.59 mils

#19 60° 58.9
85° 69.3
thk 5.64 mils

#20 60° 67.7
85° 66.8
thk 6.96

Field Service Evaluation Checklist (Continued)

Component ID: GSM, P/N 1317AS100-2

Component Name: MAN CART

Serial Number: NRR 204

Performance Criteria	Instructions	Results and Observations
Color #1	Using attached drawing, determine location to take measurement.	L 93.88 A -0.64 B 4.11 #12
Color #2	Using attached drawing, determine location to take measurement.	L 94.48 A -0.71 B 3.35 #13
Color #3	Using attached drawing, determine location to take measurement.	L 94.78 A -0.67 B 3.38 #14
Color #4	Using attached drawing, determine location to take measurement.	L 93.99 A -0.69 B 3.74 #15
Color #5	Using attached drawing, determine location to take measurement.	L 94.28 A -0.75 B 3.84 #16
Color #6	Using attached drawing, determine location to take measurement.	L 94.16 A -0.56 B 4.55 #17
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes:

(Add additional pages as necessary)

#7 L 94.55 #18
A −0.59
B 3.47

#8 L 94.74
A −0.59 #19
B 3.43

#9 L 95.0
A −0.58 Trial #5
B 3.84

#10 L 95.85
A 0.65 #6
B 3.01

#11

#12 L 92.56
A −0.55 #9
B 3.83

#13 L 92.01
A −0.61 #8
B 4.72

#14 L 93.66 #7
A −0.67
B 4.20

#15 L 93.54 Trial #4
A −0.50
B 3.86

#16

#17 L 96.02 Trial #2
A −0.69
B 2.86

#18 L 94.38 Trial #3
A −0.61
B 3.79

#19 L 94.81 #10
A −0.72
B 2.98

#20 L 93.15
A −0.42 #11
B 4.01

NRR 204

Field Service Evaluation Checklist

Component ID: GJFM, P/N 1317A5100-2

Component Name: Nitrogen Service Cart

Serial Number: NRR 204

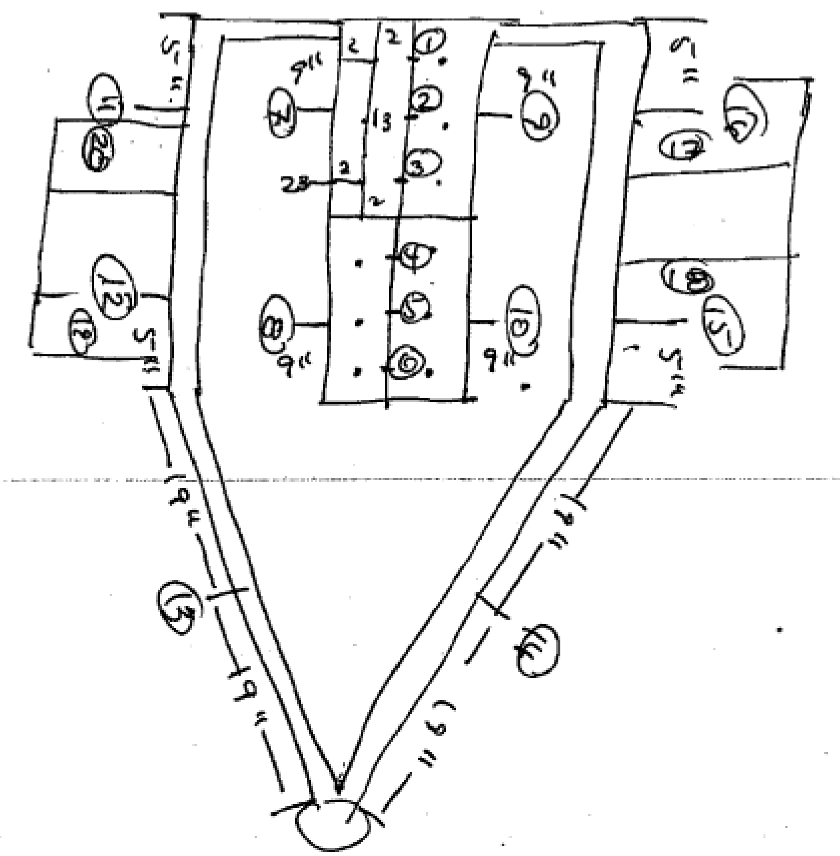
Date of Inspection: 3 February 2009

Reason For Inspection: Second Field Evaluation

Name of Inspector: ______________________

Location of Inspection: USS Ronald Reagan CVN 76

Time of Inspection: 10.25



All surfaces to be measured wiped clean after doing #1 - #3 initially.

Reading	Data		After cleaning / Comments
1	60° 72.1	L* 88.89	90.31
	85° 51.5	a* -0.13	-0.28
	DFT 6.84	b* 9.67	9.08
		Trial 20	23
2	60° 74.8	L* 88.12	90.49
	85° 88.3	a* -0.17	-0.40
	DFT 5.81	b* 9.74	9.12
		Trial 21	24
3	60° 73.3	L* 87.46	90.45
	85° 84.0	a* -0.08	-0.33
	DFT 6.25	b* 9.36	8.95
		Trial 22	25
4	60° 42.7	L* 88.74	
	85° 60.8	a* -0.28	
	DFT 5.66	b* 8.84	
		Trial 26	
5	60° 58.3	L* 89.28	
	85° 76.3	a* -0.28	
	DFT 5.09	b* 9.73	
		Trial 27	
6	60° 52.9	L* 83.20	Oil stain in area.
	85° 82.5	a* 0.46	
	DFT 7.61	b* 12.46	
		Trial 28	

7	60° 84.5 85° 90.9 DFT 5.70	L* 92.18 a* −0.59 b* 5.90 Trial 29	
8	60° 65.1 85° 79.0 DFT 6.06	L* 88.28 a* −0.19 b* 6.77 Trial 30	
9	60° 78.3 85° 91.9 DFT 9.03	L* 93.24 a* −0.46 b* 5.96 Trial 31	
10	60° 81.3 85° 97.5 DFT 7.41	L* 93.53 a* −0.59 b* 5.59 Trial 32	
11	60° 44.1 85° 57.6 DFT 10.6	L* a* b* Trial	
12	60° 53.9 85° 75.0 DFT 9.17	L* 87.73 a* −0.11 b* 7.21 Trial 33	
13	60° 54.1 85° 66.2 DFT 6.01	L* 90.34 a* −0.73 b* 6.73 Trial 34	

14	60° 61.1 85° 68.7 DFT 6.10	L* 92.25 a* -0.70 b* 6.50 Trial 35	
15	60° 28.2 85° 43.1 DFT 8.75	L* 94.41 a* -0.75 b* 4.84 Trial 36	
16	60° 35.6 85° 41.7 DFT 9.02	L* a* b* Trial	
17	60° 40.5 85° 65.7 DFT 6.01	L* 89.45 a* -0.43 b* 6.70 Trial 37	
18	60° 71.4 85° 89.0 DFT 7.85	L* 90.50 a* -0.41 b* 6.74 Trial 38	
19	60° 60.2 85° 74.6 DFT 7.30	L* 89.25 a* -0.23 b* 7.60 Trial 39	
20	60° 60.0 85° 83.2 DFT 8.08	L* 90.75 a* -0.26 b* 7.28 Trial 40	

Field Service Evaluation Checklist

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes: Much better condition overall, including straps. No undercutting. Four deep scratches on horizontal panel w/corrosion starting. Abrasion on bottle has worn down to bare metal, corrosion beginning

(Add additional pages as necessary)

Field Service Evaluation Checklist

Component ID: GJFM, P/N 1317A5100-2

Component Name: Nitrogen Service Cart

Serial Number: NRR 204

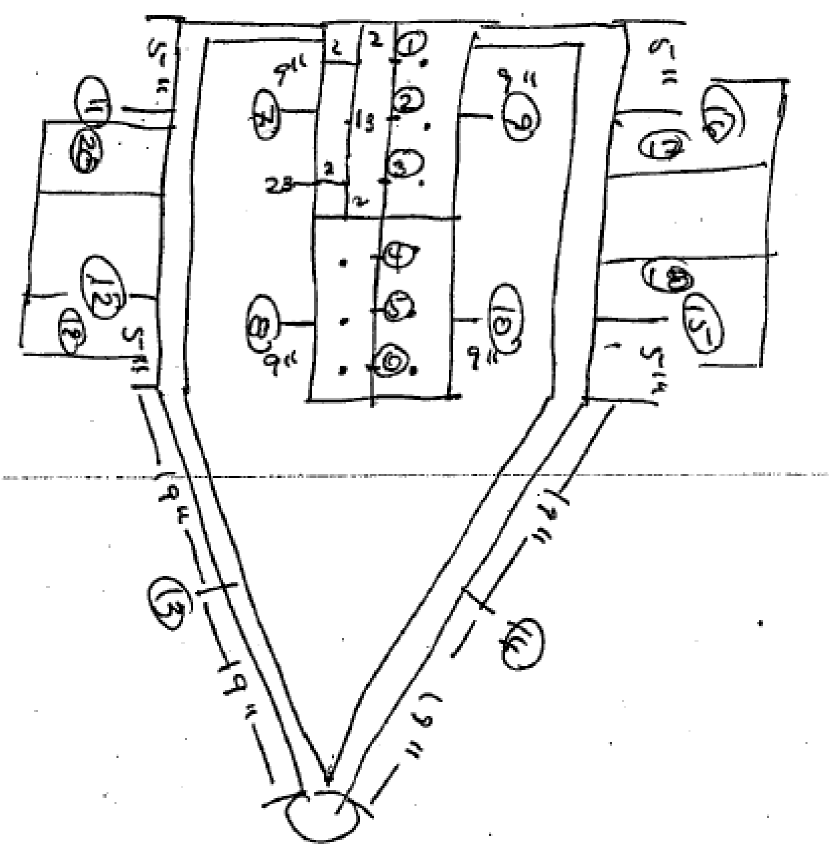
Date of Inspection: 4 November 2009

Reason For Inspection: Third Field Evaluation

Name of Inspector: Steve Turley

Location of Inspection: USS Ronald Reagan CVN 76

Time of Inspection: 11.25



Reading	Data	Comments
1	60° 46.1 L* 85° 79.4 a* DFT 6.39 b* Trial	
2	60° 52.5 L* 85° 79.0 a* DFT 5.59 b* Trial	
3	60° 46.4 L* 85° 78.3 a* DFT 6.18 b* Trial	
4	60° 28.7 L* 85° 72.7 a* DFT 5.54 b* Trial	
5	60° 38.9 L* 85° 70.2 a* DFT 5.81 b* Trial	
6	60° 34.0 L* 85° 71.3 a* DFT 6.40 b* Trial	Stain in measurement area.

7	60° 59.7 L* 85° 88.2 a* DFT 5.52 b* Trial	
8	60° 55.0 L* 85° 74.3 a* DFT 5.56 b* Trial	
9	60° 44.1 L* 85° 86.2 a* DFT 9.20 b* Trial	
10	60° 69.3 L* 85° 89.3 a* DFT 7.45 b* Trial	
11	~~60° 10.2~~ L* ~~85° 36.1~~ a* ~~DFT 12.0~~ b* Trial	60°: 57.6 85°: 81.5 DFT: 11.9 Rewipe prior to new readings.
12	60° 49.0 L* 85° 79.3 a* DFT 8.61 b* Trial	
13	~~60° 28.6~~ L* ~~85° 54.5~~ a* ~~DFT 5.94~~ b* Trial	60°: 50.9 85°: 56.9 DFT: 4.97 Rewipe prior to new readings. Moved off of scratch.

14	60° 63.6 L* 85° 82.4 a* DFT 7.56 b* Trial	
15	60° 69.4 L* 85° 87.8 a* DFT 10.1 b* Trial	
16	60° L* 85° a* DFT b* Trial	Rusted/worn area due to tie-down chain prevents taking reading.
17	60° 42.0 L* 85° 75.1 a* DFT 5.85 b* Trial	
18	60° 67.6 L* 85° 89.9 a* DFT 7.55 b* Trial	
19	60° 56.5 L* 85° 86.9 a* DFT 7.14 b* Trial	
20	60° 39.8 L* 85° 81.3 a* DFT 8.19 b* Trial	

Field Service Evaluation Checklist

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes: Much less surface than -073; however, Bottles much more corroded.
Bottles are not dedicated to the cart! They may be changed out and replaced.

(Add additional pages as necessary)

MONTHLY EVALUATION OF COATED COMPONENT LOG

Component Serial No. NRR204
Evaluating Activity USS RONALD REAGAN CVN-76

Date of Inspection 04 NOV 08

	Yes	**No**
Is the component completely coated?	X	
Is the component free from corrosion?	X	
Overall, is the coating system holding up well?	X	
Is the component free from chipping?	X	
Is the component free from flaking or peeling?	X	
Is the coating free from discoloration?	X	

Comments and observations: CONDITION OF UNIT IS WITH STANDING FLIGHT DECK USE ON A DAILY BASIS. MINOR SCRATCHES ON FENDERS AND MAIN FRAME BUT OVER-ALL POWDER COATING IS STILL GOOD. NITROGEN BOTTLES HAVE BEEN REPAINTED DUE TO SURFACE CORROSION.

MONTHLY EVALUATION OF COATED COMPONENT LOG

Component Serial No. NRR204
Evaluating Activity USS RONALD REAGAN CVN-76

Date of Inspection 06 JAN 09

	Yes	**No**
Is the component completely coated?	X	
Is the component free from corrosion?	X	
Overall, is the coating system holding up well?	X	
Is the component free from chipping?	X	
Is the component free from flaking or peeling?	X	
Is the coating free from discoloration?	X	

Comments and observations: CONDITION OF UNIT IS STILL THE SAME AS REPORTED IN NOVEMBER 2008. MINOR SCRATCHES ON FENDERS AND MAIN FRAME BUT OVER-ALL POWDER COATING IS STILL GOOD. NITROGEN BOTTLES HAVE BEEN REPAINTED DUE TO SURFACE CORROSION.

Table 84. J52 Aft Engine Yoke P9H513 Raw Data

Field Service Evaluation Checklist #1

Component ID: PWA-14408

Component Name: Aft Engine Yoke

Serial Number: P9H513

Date of Inspection: 1/30

Name of Inspector: SF

Location of Inspection: FRC NW 900 Div.

Time of Inspection: 12:50

Part arrival in Paint Shop, Date, Time: N/A

Earliest Date, Time when part could depart: N/A

Preheat time (if any): 60, TYP minutes

Time to apply powder on component: 5, TYP. minutes

Amount of powder applied (pounds): N/A

Complete following if doing a two pass coating

1st Bake (if applicable): 30, TYP minutes

Second powder application (if applicable): N/A minutes

Amount of powder in second coat (if applicable)(pounds): N/A

Complete the following for all applications

Full bake time: 30, TYP. minutes

Time from bake end to de-mask start (cool down time): 10, TYP. minutes

Field Service Evaluation Checklist #2

Component ID: PWA – 14408

Component Name: Aft Engine Yoke

Serial Number: P9H513

Date of Inspection: 1/30

Name of Inspector: SF

Location of Inspection: FRC 900 DIV.

Time of Inspection: 12.15

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	surface roughness affected readings d.f.t
Gloss #7	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 22.0 85° 20.2 3.9 5.2 2.7
Gloss #8	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 37.0 85° 41.4 3.0 4.2 3.6
Gloss #9	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 33.8 85° ~~[illegible]~~ 41.1 2.1 1.75 1.9
Gloss #10	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 41.6 85° 34.8 2.8 2.2 4.3
Gloss #5	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	
Gloss #6	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	

Field Service Evaluation Checklist (Continued)

Component ID: PWA-14408

Component Name: Aft Engine Yoke

Serial Number: P9H513

Performance Criteria	Instructions	Results and Observations	d.f.t
Color #1	Using attached drawing, determine location to take measurement.	L 89.37 A -1.13 B 3.52 Trial 23	2.3 2.6 3.4
Color #2	Using attached drawing, determine location to take measurement.	L 88.08 A -1.29 B 2.53 Trial 24	1.45 1.65 1.9
Color #3	Using attached drawing, determine location to take measurement.	L 93.12 A -1.06 B 4.82 Trial 25	3.2 2.6 2.5
Color #4	Using attached drawing, determine location to take measurement.	L 93.96 A -0.96 B 4.64 Trial 26	2.9 3.4 3.0
Color #5	Using attached drawing, determine location to take measurement.	L 93.97 A -0.89 B 4.51 Trial 27	3.7 4.0 3.8
Color #6	Using attached drawing, determine location to take measurement.	L 94.33 A -1.03 B 4.08 Trial 28	3.7 3.8 3.6
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.		
Adhesion	Visibly inspect component for obvious indications of adhesion loss.		

Additional Notes: ______

(Add additional pages as necessary)

Field Service Evaluation Checklist

Component ID: PWA-14408

Component Name: AFT Engine Yoke

Serial Number: P9H513

Date of Inspection: 17 July 2008

Reason For Inspection: Second Field Evaluation

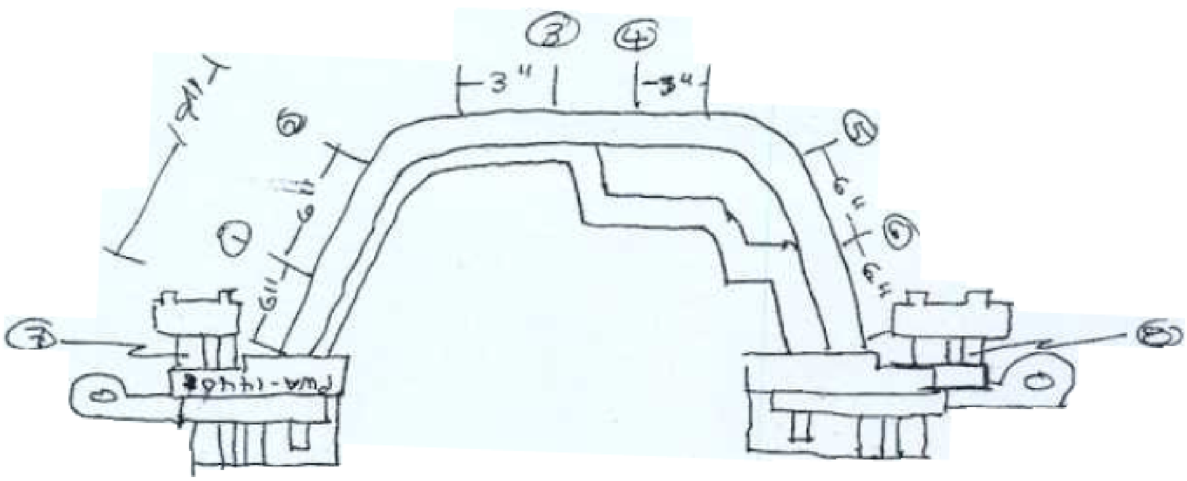
Name of Inspector: Steve Finley

Location of Inspection: FRC NW 900 Div

Time of Inspection:

NOTE: All Readings Taken From Side Showing P/N

Data is the result of the average of three readings per location



9, 0 reverse side from 7,

Reading	Data	Comments
1	60° NT L* 93.06 85° NT a* -0.44 DFT NT 5.6 b* 3.55 Trail 56	
2	60° NT L* 90.33 85° NT a* -0.86 DFT NT 2.3 b* 1.80 Trail 57	
3	60° NT L* 90.60 85° NT a* -0.79 DFT NT 3.6 b* 2.42 Trail 58	
4	60° NT L* 90.96 85° NT a* -0.58 DFT NT 3.5 b* 2.77 Trail 59	
5	60° NT L* 92.94 85° NT a* -0.56 DFT NT 3.9 b* 3.08 Trail 60	
6	60° NT L* 93.83 85° NT a* -0.68 DFT NT 4.0 b* 2.68 Trail 61	

7	60° 26.5 L* NT 85° 37.9 a* NT DFT 5.94 b* NT Trail NT	
8	60° 23.9 L* NT 85° 33.9 a* NT DFT 4.32 b* NT Trail	
9	60° 22.0 L* NT 85° 38.3 a* NT DFT 2.62 b* NT Trail NT	
10	60° 16.8 L* NT 85° 26.8 a* NT DFT 2.6 b* NT Trail NT	

Field Service Evaluation Checklist

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	Surface roughness of either the substrate or coating,
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

The only one In VAQ-132's hangar

Additional Notes: Surface roughness affected readings

less chipping and abrasion on feet.

(Add additional pages as necessary)

Field Service Evaluation Checklist

Component ID: PWA-14408

Component Name: AFT Engine Yoke

Serial Number: P9H513

Date of Inspection: 27 Jan 2009

Reason For Inspection: Third Field Evaluation

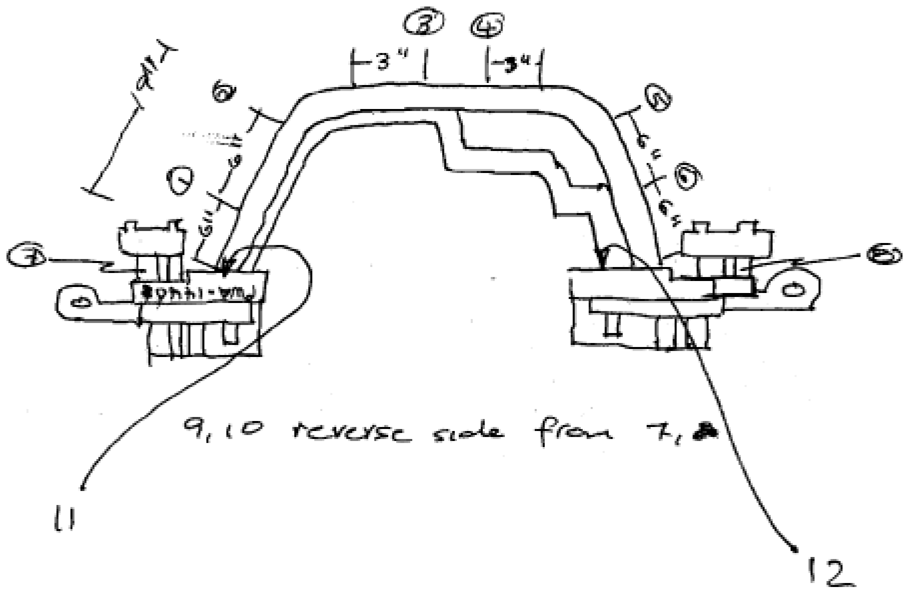
Name of Inspector: Steve Finley

Location of Inspection: FRC NW 900 Div

Time of Inspection:

NOTE: All Readings Taken From Side Showing P/N

Data is the result of the average of three readings per location



Reading	Data	Comments
1	60° NT 15.3 L* 94.48 85° NT 61.1 a* -0.69 DFT ~~1.5~~ 3.9 b* 2.58 Trial —	
2	60° NT 39.0 L* 93.12 85° NT 43.6 a* -0.85 DFT ~~1.05~~ b* 1.88 5.7 ~~5.5~~ Trial —	
3	60° NT 31.9 L* 90.38 85° NT 55.9 a* -0.64 DFT 3.2 b* 2.90 Trial —	
4	60° NT 41.0 L* 91.47 85° NT 55.8 a* -0.68 DFT 2.8. b* 2.48 Trial —	
5	60° NT 32.0 L* 93.29 85° NT 35.8 a* -0.57 DFT 3.3 b* 2.87 Trial —	
6	60° NT 39.5 L* 93.26 85° NT 72.5 a* -0.08 DFT 2.5 b* 2.52 Trial —	

7	60° L* NT 85° a* NT DFT 2.5 b* NT Trial NT	Part in way, preventing measurement
8	60° L* NT 85° a* NT DFT 2.5 b* NT Trial NT	"
9	60° L* NT 85° a* NT DFT 5.5 b* NT Trial NT	"
10	60° L* NT 85° a* NT DFT 2.5 b* NT Trial NT	"

11 60° 55.3 L 95.37
85° 66.3 a −0.45
6.6 b 3.42
Trial

12 60° 55.7 L 92.96
85° 75.4 a −0.40
5.6 b 3.98
Trial

Field Service Evaluation Checklist

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes:

Some drag wear but minimal abrasion.
Wear on bottom of tube.

(Add additional pages as necessary)

Table 85. C-130 Nose Landing Gear Forward and Aft Doors Raw Data

AirCraft C-130 Wyoming ANG 92-1534

Forward Door

Initial Paint May 2008

Color	Gloss 60˚/85˚	Thickness (mil)
L=66.23 a=-4.92 b=1..48 E=66.4	43.5/27.2	3.8 3.1 3.5
L=66.10 a=-4.86 b=1.41 E=66.3	34.4/20.4 35.3/25.3 48.3/29.8	3.5 2.8 3.0
L=66.00 a=-4.78 b=1.38 E=66.2	30.9/20.0 22.7/14.7 37.8/25.1	3.2 2.7 2.4
L=66.00 a=-4.79 b=1.46 E=66.2	38.7/19.0 25.0/12.8	2.5 3.1 3.4

Aft Door

Color			Gloss 60˚/85˚			Thickness		
L=66.06 a-4.87 b=1.35 E=66.3	L=66.16 a=-4.79 b=1.34 E=66.3	L=66.13 a=-4.79 b=1.76 E=66.3	53/40.2 45.6/33.5	37.6/32.6 44.5/34.2	34.3/26.3 41.1/31.1	2.8 2.1 1.95	2.1 1.9 1.8	2.2 1.9 1.8

Note: These diagrams represent the rough shape and design of the forward and aft doors. Reported measurements are placed in their approximate locations.

Powder coating results on C-130 doors AC #92-1534.xls May 2008

AirCraft C-130 Wyoming ANG 92-1534

Forward Door

Jul-09

Section	Color	Gloss 60˚/85˚	Thickness (mil)
1	L= 66.25 a= -4.95 b= 1.08 E= 66.443	42/28	3.2 2.9 2.8
2	L= 66.32 a= -4.95 b= 1.06 E= 66.513	34/20 40/32	3.5 3.0 3.4
3	L= 66.02 a= -4.99 b= 1.09 E= 66.217	35/24 35/27	2.7 2.8 2.1
4	L= 66.2 a= -4.94 b= 1.19 E= 66.395	36/25 32/23	3.1 3.4 3.4

Aft Door

Color

Left	Center	Right
L= 66.02 a= -4.78 b= 1.02 E= 66.201	couldn't reach... dirty	L= 66.25 a= -4.7 b= 1.1 E= 66.426

Gloss 60˚/85˚

Left	Center	Right
53/40.2 45.6/33.5	couldn't reach... dirty	34.3/26.3 41.1/31.1

Thickness

Left	Center	Right
3.0 2.5 2.2	couldn't reach... dirty	2.5 2.2 1.9

Note: These diagrams represent the rough shape and design of the forward and aft doors. Reported measurements are placed in their approximate locations.

Table 86. 20 Ton Jack (SN: 088010) Raw Data

Field Service Evaluation Checklist #1

Component ID:

Component Name: 20 TON JACK

Serial Number: 088010

Date of Inspection: 8/11/09

Name of Inspector: S. FINLEY

Location of Inspection: FRC-NW

Time of Inspection: 10.55

Part arrival in Paint Shop, Date, Time:

Earliest Date, Time when part could depart: 06 APR 09

Preheat time (if any): 30 minutes

Time to apply powder on component: 15 minutes

Amount of powder applied (pounds):

Complete following if doing a two pass coating

1st Bake (if applicable): minutes

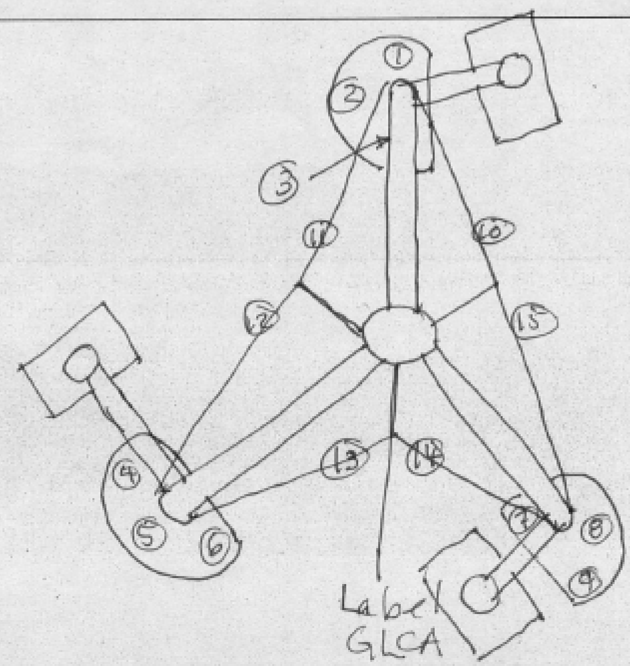
Second powder application (if applicable): minutes

Amount of powder in second coat (if applicable)(pounds):

Complete the following for all applications

Full bake time: 30 minutes

Time from bake end to de-mask start (cool down time): 30 minutes



Field Service Evaluation Checklist #2

Component ID: 20 TON JACK

Component Name:

Serial Number: 088010

Date of Inspection: 8/11

Name of Inspector:

Location of Inspection:

Time of Inspection: 10.55

Edge ridge prevents taking readings

Reading	Data		Comments
1	60°	L* 97.05	
	85°	a* -0.41	
	DFT	b* 3.21	
		Trail 175	
2	60°	L* 97.15	
	85°	a* -0.55	
	DFT	b* 3.61	
		Trail 176	
3	60°	L* 96.76	
	85°	a* -0.71	
	DFT	b* 3.94	
		Trail 177	
4	60°	L* 96.44	Chip (minor) due to mechanical abrasion.
	85°	a* -0.54	
	DFT	b* 3.91	
		Trail 178	
5	60° 76.5	L* 96.97	Chipping due to mechanical abrasion.
	85° NT 77.6	a* -0.52	
	DFT NT 17.4	b* 3.96	
		Trail 179	

#5.5 60° 74.8
85° 79.8
DFT 19.6

6	60° 71.3 85° 88.2 DFT 17.0	L* 97.22 a* -0.54 b* 3.87 Trail (80)	
7	60° 85° DFT	L* 95.06 a* -0.52 b* 3.32 Trail (81)	
8	60° 61.1 85° 75.1 DFT 9.3	L* 96.39 a* -0.76 b* 2.64 Trail 183	(redid reading)
9	60° 85° DFT	L* a* b* Trail	No contact
10	60° 76.0 85° 95.0 DFT ~~21.8~~ 9.72	L* a* b* Trail	

11 60° 70.7
85° 87.7
DFT 10.5

12 60° 73.4
85° 90.8
DFT 8.44

13 60° 71.8
85° 95.5
DFT 7.01

Field Service Evaluation Checklist (Continued)

Component ID:

Component Name: 20 TON JACK

Serial Number: 088910

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes:

(Add additional pages as necessary)

14 60° 76.2 Mechanical wear and tear
85° 93.5
DFT 10.6

15 60° 74.1
85° 96.1
DFT 8.12

Table 87. Air Breathing Pump Assembly (SN: P62008) Raw Data

Field Service Evaluation Checklist #1

Component ID: NF15-3

Component Name: Air Breathing Pump Assembly

Serial Number: P62008

Date of Inspection: 4/21/09.

Name of Inspector: Steve Finley

Location of Inspection: FRC-NW

Time of Inspection: 0945

Part arrival in Paint Shop, Date, Time: 4/17/09

Earliest Date, Time when part could depart: 4/17/09

Preheat time (if any): 30 minutes

Time to apply powder on component: 15 minutes

Amount of powder applied (pounds): unknown

Complete following if doing a two pass coating

1st Bake (if applicable): ______ minutes

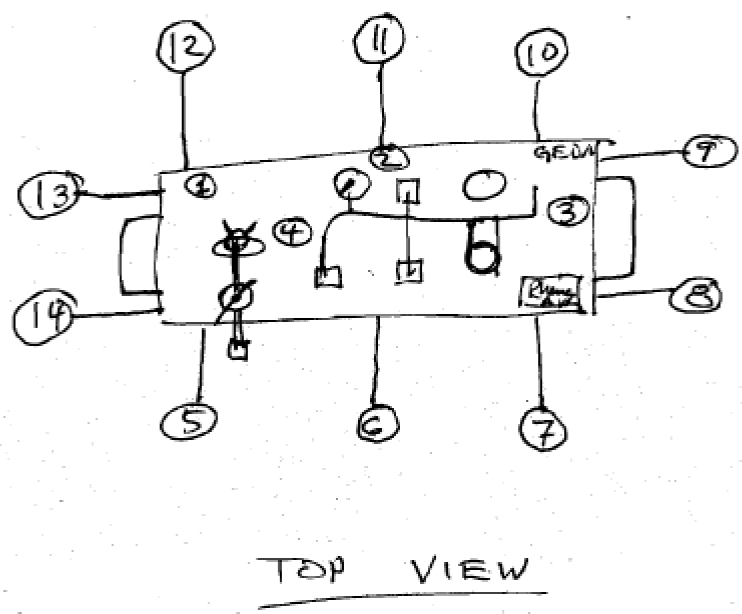
Second powder application (if applicable): ______ minutes

Amount of powder in second coat (if applicable)(pounds): ______

Complete the following for all applications

Full bake time: ______ minutes

Time from bake end to de-mask start (cool down time): ______ minutes



Field Service Evaluation Checklist #2

Component ID: NF15-3

Component Name: Air Breathing Pump Assembly

Serial Number: PG2008

Date of Inspection: 4/21/09

Name of Inspector: Steve Finley

Location of Inspection: FRC - NW

Time of Inspection: 0945

Reading	Data				Comments
1	60°	89.7	L*	96.43	
	85°	—	a*	-0.57	
	DFT	5.83	b*	5.44	
	20°	41.3	Trail	73	
2	60°	85.8	L*	96.36	
	85°	—	a*	-0.59	
	DFT	6.33	b*	5.64	
	20°	59.0	Trail	74	
3	60°	73.2	L*	94.92	
	85°	—	a*	-1.12	
	DFT	2.32	b*	3.57	
	20°	29.0	Trail	75	
4	60°	85.9	L*	96.16	
	85°	—	a*	-0.70	
	DFT	4.93	b*	5.19	
	20°	48.6	Trail	76	
5	60°	85.1	L*	96.42	
	85° NT	—	a*	-0.59	
	DFT NT	6.22	b*	5.52	
	20°	35.4	Trail	77	

6	60°	89.8	L*	96.29	
	85°	–	a*	-0.72	
	DFT	5.17	b*	5.16	
	20°	57.0	Trail	78	
7	60°	87.2	L*	96.0	
	85°	–	a*	-0.83	
	DFT	4.98	b*	4.88	
	20°	49.2	Trail	79	
8	60°	89.1	L*		
	85°	–	a*		
	DFT	5.79	b*		
	20°	56.8	Trail		
9	60°	70.3	L*		
	85°	–	a*		
	DFT	5.50	b*		
	20°	23.8	Trail		
10	60°	79.1	L*	96.65	
	85°	–	a*	-0.44	
	DFT	5.83	b*	5.75	
	20°	23.6	Trail	80	

11 60° 91.4 L 96.18

DFT 7.90 a -0.74

20° 66.0 b 5.11

Trial 81

12 60° 91.6

DFT 5.54

20° 65.5

L 96.49

a -0.53

b 5.54

Trial 82

Field Service Evaluation Checklist (Continued)

Component ID:____

Component Name:______________________________________

Serial Number:____

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes:______________________________________

(Add additional pages as necessary)

13 60° 90.4

DFT 4.07

20° 61.4

14 60° 91.0

DFT 4.69

20° 60.9

Field Service Evaluation Checklist

Component ID: NF15-3

Component Name: Air Breathing Pump Assy.

Serial Number: P62008

Date of Inspection: 8/11/09

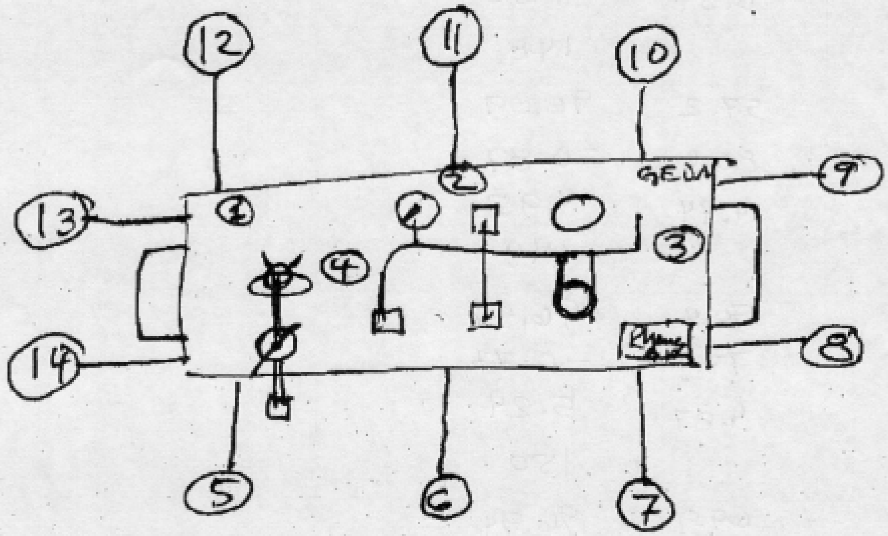
Reason For Inspection:

Name of Inspector: S. FINLEY

Location of Inspection: FRE-NW

Time of Inspection: 09.45

NOTE:



TOP VIEW

Reading	Data	Comments
1	60° 63.1 L* 96.07 85° 88.2 a* -0.91 DFT 5.10 b* 4.89 Trial 147	
2	60° 63.3 L* 96.52 85° 93.4 a* -0.66 DFT 6.54 b* 5.53 Trial 148	
3	60° 57.2 L* 96.09 85° 80.6 a* -0.89 DFT 4.74 b* 4.95 Trial 149	
4	60° 70.4 L* 96.49 85° 77.9 a* -0.77 DFT 4.87 b* 5.24 Trial 150	
5	60° 69.9 L* 96.94 85° 73.7 a* -0.60 DFT 6.06 b* 5.58 Trial 151	
6	60° 81.0 L* 96.77 85° 92.5 a* -0.76 DFT 5.21 b* 5.19 Trial 152	

7	60° 82.6 L* 96.45 85° 90.4 a* −0.93 DFT 5.35 b* 4.81 Trial 153	
8	60° 73.3 L* 94.79 85° 94.0 a* −0.55 DFT 5.98 b* 5.41 Trial 154	
9	60° 62.8 L* 94.01 85° 65.8 a* −0.92 DFT 5.12 b* 4.45 Trial 155	
10	60° 84.8 L* 97.01 85° 84.9 a* −0.59 DFT 6.08 b* 5.54 Trial 156	
11	60° 84.9 L* 97.08 85° 92.0 a* −0.50 DFT 7.61 b* 5.80 Trial 157	
12	60° 87.9 L* 96.58 85° 88.7 a* −0.82 DFT 5.63 b* 5.10 Trial 158	
13	60° 86.2 L* 95.38 85° 87.7 a* −1.04 DFT 4.13 b* 4.27 Trial 159	

14	60° 74.8 L* 95.68 85° 75.4 a* −0.84 DFT 5.29 b* 5.08 Trial 160	

Field Service Evaluation Checklist #2

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes:

(Add additional pages as necessary)

Table 88. Air Breathing Pump Assembly (SN: RDX435) Raw Data

Field Service Evaluation Checklist #1

Component ID: NF15 - 3

Component Name: Air Breathing Pump Assembly

Serial Number: RDX 435

Date of Inspection: 4/21/09

Name of Inspector: Steve Finley

Location of Inspection: FRC- NW

Time of Inspection: 1035

Part arrival in Paint Shop, Date, Time: 4/9/09

Earliest Date, Time when part could depart: 4/9/09

Preheat time (if any): 30 minutes

Time to apply powder on component: 15 minutes

Amount of powder applied (pounds): unknown

Complete following if doing a two pass coating

1st Bake (if applicable):________ minutes

Second powder application (if applicable):________ minutes

Amount of powder in second coat (if applicable)(pounds):________

Complete the following for all applications

Full bake time:________ minutes

Time from bake end to de-mask start (cool down time):________ minutes

Field Service Evaluation Checklist #2

Component ID: NF15-3
Component Name: Air Breathing Pump Assembly
Serial Number: RDX 435

Date of Inspection: 4/21/09
Name of Inspector: Steve Finley
Location of Inspection: FRC-NW
Time of Inspection: 1035

Reading	Data				Comments
1	60°	78.5	L*	94.36	Chips near data point #1 and #14.
	85°	—	a*	-1.43	
	DFT	2.94	b*	4.98	
	20°	32.4	Trail	83	
2 85.7	60°	~~56.2~~	L*	94.92	New readings in front of tall filter. Original is really flat and orange peel.
—	85°	–	a*	-1.17	
2.62	DFT	~~3.10~~	b*	3.57	
53.6	20°	~~18.7~~	Trail	84	
3	60°	80.6	L*	95.08	
	85°	–	a*	-1.16	
	DFT	2.88	b*	3.56	
	20°	47.1	Trail	85	
4	60°	77.9	L*	95.13	
	85°	—	a*	-1.07	
	DFT	3.41	b*	4.12	
	20°	37.6	Trail	86	
5	60°	79.5	L*	95.13	
	85° NT	–	a*	-1.07	
	DFT NT	2.94	b*	4.12	
	20°	38.4	Trail	87	

6	60° 91.9	L*	95.39	
	85° —	a*	-1.12	
	DFT 3.19	b*	3.71	
	20° 65.9	Trail	87	
7	60° 89.7	L*	95.75	
	85° —	a*	-1.03	
	DFT 3.96	b*	4.19	
	20° 62.2	Trail	88	
8	60° 69.5	L*		Dent close to flange.
	85° —	a*		
	DFT 2.69	b*		
	20° 30.3	Trail		
9	60° 73.4	L*		
	85° —	a*		
	DFT 3.26	b*		
	20° 37.1	Trail		
10	60° 86.3	L*	95.9	
	85° —	a*	-0.18	
	DFT 3.82	b*	4.82	
	20° 42.7	Trail	89	

11 60° 73.5 L* 95.36
DFT 3.50 a* -1.11
20° 26.0 b* 3.82
Trial 90

12 60° 67.5 L* 95.93
DFT 4.10 a* -0.88
20° 22.4 b* 4.68
Trial 91

Field Service Evaluation Checklist (Continued)

Component ID:________________________________

Component Name:______________________________

Serial Number:________________________________

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes:______________________________

(Add additional pages as necessary)

13	60°	57.2
	DFT	4.75
	20°	21.3
14	60°	39.8
	DFT	4.01
	20°	23.7

Field Service Evaluation Checklist

Component ID: NF15-3

Component Name: Air Breathing Pump Assy.

Serial Number: RDX435

Date of Inspection: 8/11/09

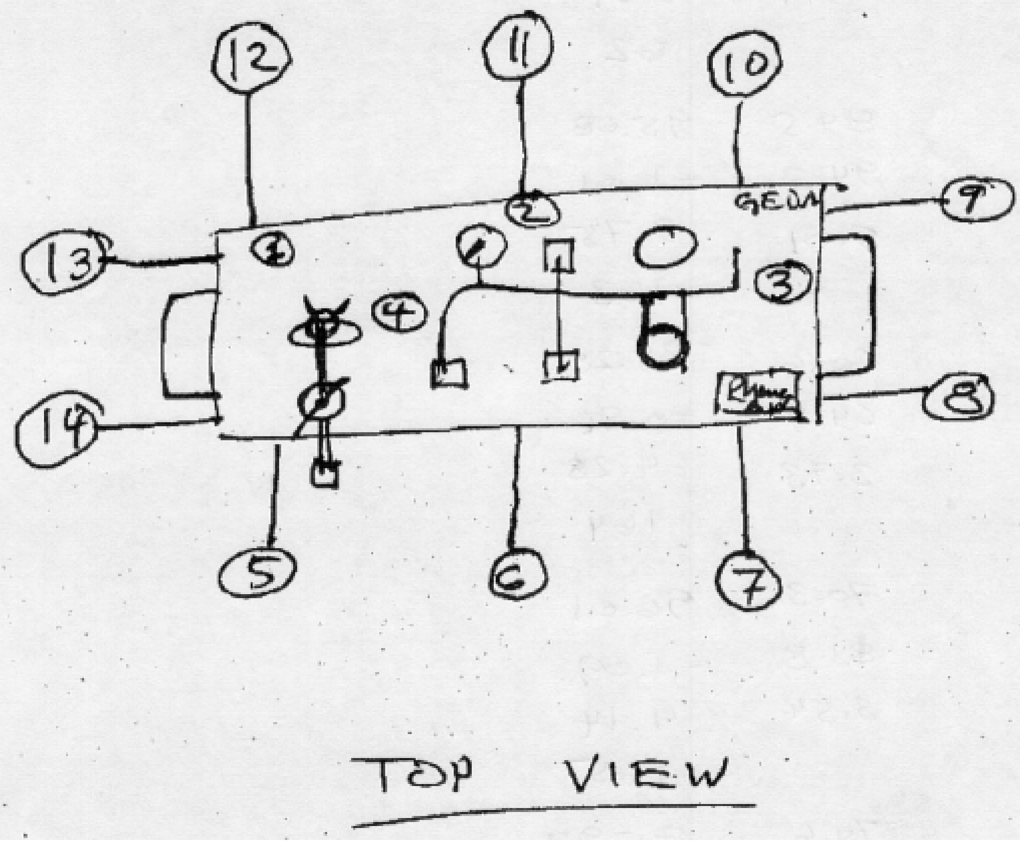
Reason For Inspection:

Name of Inspector: S. FINLEY

Location of Inspection:

Time of Inspection: 10.08

NOTE:



Reading	Data	Comments
1	60° 63.5 L* 94.25 85° 76.2 a* −1.00 DFT 3.05 b* 4.75 Trial 161	
2	60° 59.2 L* 94.24 85° 63.7 a* −0.79 DFT 3.77 b* 5.04 Trial 162	
3	60° 84.5 L* 95.08 85° 94.3 a* −1.01 DFT 3.01 b* 3.75 Trial 163	
4	60° 60.6 L* 95.28 85° 64.9 a* −0.96 DFT 3.73 b* 4.28 Trial 164	
5	60° 70.3 L* 96.01 85° 81.8 a* −1.09 DFT 3.54 b* 4.14 Trial 165	
6	60° 74.6 L* 95.92 85° 94.3 a* −1.15 DFT 3.35 b* 3.84 Trial 166	

7	60° 70.7 L* 96.27 85° 93.2 a* -1.07 DFT 4.23 b* 4.25 Trial 167	
8	60° 67.4 L* 94.72 85° 55.6 a* -1.21 DFT 2.74 b* 3.57 Trial 168	
9	60° 78.4 L* 95.26 85° 95.5 a* -1.17 DFT 3.46 b* 3.92 Trial 169	
10	60° 72.8 L* 96.76 85° 74.9 a* -0.88 DFT 4.51 b* 4.99 Trial 170	
11	60° 65.6 L* 95.81 85° 68.6 a* -1.14 DFT 3.48 b* 3.88 Trial 171	
12	60° 53.5 L* 96.07 85° 42.5 a* -1.03 DFT 3.68 b* 4.38 Trial 172	No real reason for these low readings.
13	60° 56.1 L* 95.73 85° 64.8 a* -1.00 DFT 4.58 b* 4.65 Trial 173	

14	60° 61.3 L* 95.73 85° 68.4 a* -1.03 DFT 4.16 b* 4.32 Trial 174	

Field Service Evaluation Checklist #2

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes: Paint scraped (chipped) off due to abrasion above #1 due to regulator. Mechanical damage only.

(Add additional pages as necessary)

Table 89. J52 Aft Engine Yoke (SN: 00635A) Raw Data

Field Service Evaluation Checklist #1

Component ID: ____________________
Component Name: Engine Yoke
Serial Number: TEC: GMRD, S/n 00635A

Date of Inspection: 4/21/09
Name of Inspector: Steve Finley
Location of Inspection: FRC - NW
Time of Inspection: 11:10

Part arrival in Paint Shop, Date, Time: 4/14/09
Earliest Date, Time when part could depart: 4/14/09
Preheat time (if any): 30 minutes
Time to apply powder on component: 15 minutes
Amount of powder applied (pounds): unk

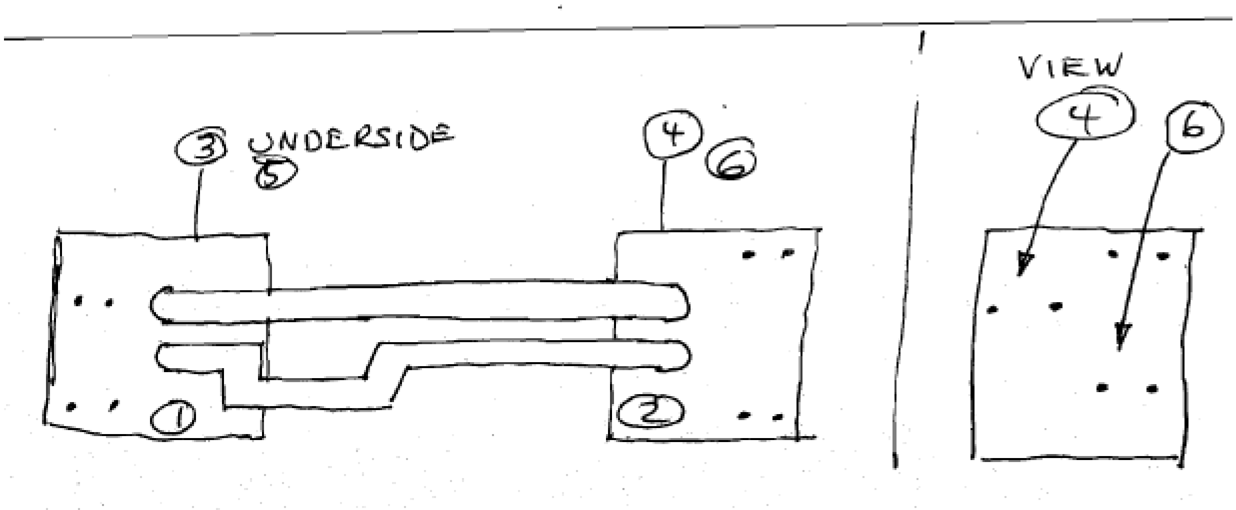
Complete following if doing a two pass coating

1st Bake (if applicable): __________ minutes
Second powder application (if applicable): __________ minutes
Amount of powder in second coat (if applicable)(pounds): __________

Complete the following for all applications

Full bake time: __________ minutes

Time from bake end to de-mask start (cool down time): __________ minutes



TOP DOWN UNDERSIDE VIEW

Field Service Evaluation Checklist #2

Component ID:
Component Name: Engine Yoke
Serial Number: 00635A

Date of Inspection: 4/21/09
Name of Inspector: Steve Finley
Location of Inspection: FRC-NW
Time of Inspection: 11:10

Reading	Data				Comments
1	60°	65.5	L*	96.34	
	85°	–	a*	-0.66	
	DFT	5.39	b*	5.24	
	20°	21.2	Trail	92	
2	60°	60.9	L*	94.80	
	85°	—	a*	-0.98	
	DFT	3.74	b*	4.29	
	20°	17.2	Trail	93	
3	60°	79.7	L*	96.56	
	85°	–	a*	-0.31	
	DFT	10.2	b*	5.87	
	20°	36.8	Trail	94	
4	60°	58.7	L*	95.82	Rough ~~coating~~ substrate
	85°	–	a*	-0.95	
	DFT	3.65	b*	4.61	
	20°	17.6	Trail	95	
5	60°	64.5	L*	95.69	Rough substrate
	85° NT	–	a*	-0.63	
	DFT NT	6.36	b*	5.39	
	20°	23.0	Trail	96	

6	60° 50.1 L* 95.81 85° — a* −0.87 DFT 4.02 b* 4.70 20° 14.1 Trail 97	Rough substrate
7	60° L* 85° a* DFT b* Trail	
8	60° L* 85° a* DFT b* Trail	
9	60° L* 85° a* DFT b* Trail	
10	60° L* 85° a* DFT b* Trail	

Field Service Evaluation Checklist (Continued)

Component ID:____

Component Name:______________________________________

Serial Number:____

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes:____

(Add additional pages as necessary)

Table 90. J52 Aft Engine Yoke (SN: 800-242) Raw Data

Field Service Evaluation Checklist #1

Component ID: PWA-4408
Component Name: Aft Engine Yoke
Serial Number: 800-242

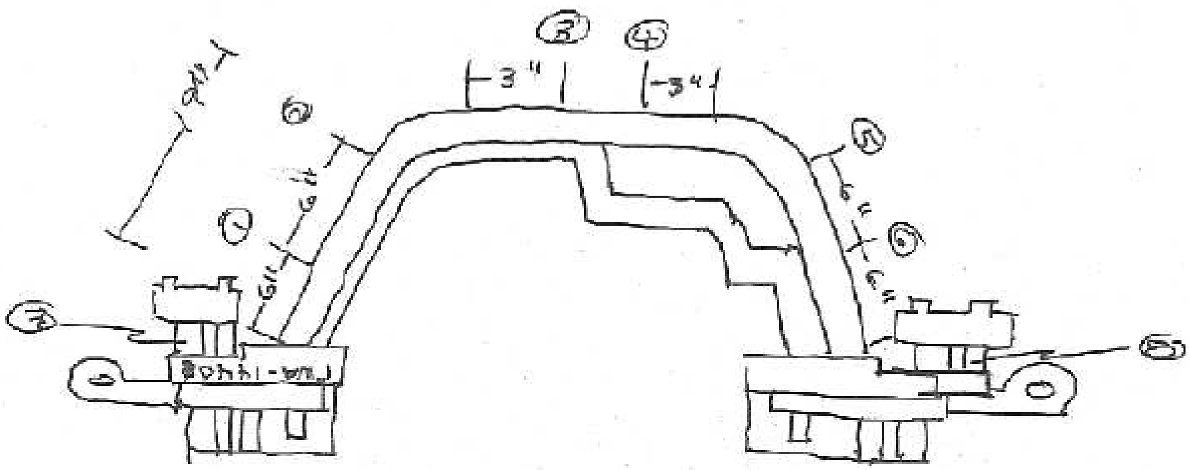
Date of Inspection: 1/30
Name of Inspector: SF
Location of Inspection: FRC NW 900 DIV
Time of Inspection: 12:35

Part arrival in Paint Shop, Date, Time: N/A
Earliest Date, Time when part could depart: N/A
Preheat time (if any): 60, TYP. minutes
Time to apply powder on component: 5, TYP. minutes
Amount of powder applied (pounds): N/A

Complete following if doing a two pass coating
1st Bake (if applicable): 30 TYP. minutes
Second powder application (if applicable): N/A minutes
Amount of powder in second coat (if applicable)(pounds): N/A

Complete the following for all applications
Full bake time: 30 TYP. minutes

Time from bake end to de-mask start (cool down time): 10 TYP. minutes



9, 10 reverse side from 7, 8

Field Service Evaluation Checklist #2

Component ID: PWA-14408
Component Name: Engine Yoke, Aft
Serial Number: 000242

Date of Inspection: 1/30
Name of Inspector: SF
Location of Inspection: FLC 900 DIV
Time of Inspection: 12:35

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Gloss #7	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 71.7 85 90.5
Gloss #8	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 76.5 85° 73.1
Gloss #9	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 79.9 85.° 90.0
Gloss #10	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 79.7 85.° 96.4
Gloss #5	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	
Gloss #6	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	

Field Service Evaluation Checklist (Continued)

Component ID: PWA-14408
Component Name: Aft Engine Yoke
Serial Number: 000242

Performance Criteria	Instructions	Results and Observations		dft
Color #1	Using attached drawing, determine location to take measurement.	L 85.22 A -0.59 B 4.53	Trial 11	4.2 4.0 4.2
Color #2	Using attached drawing, determine location to take measurement.	L 75.71 A -0.59 B 4.12	Trial 12	3.5 3.6 3.4
Color #3	Using attached drawing, determine location to take measurement.	L 94.59 A -0.56 B 5.30	Trial 13	~~7~~ 2.5 4.1 5.3
Color #4	Using attached drawing, determine location to take measurement.	L 94.93 A -0.77 B 4.77	Trial 14	3.8 3.6 4.1
Color #5	Using attached drawing, determine location to take measurement.	L 91.96 A -0.88 B 3.96	Trial 15	3.2 3.1 3.5
Color #6	Using attached drawing, determine location to take measurement.	L 86.73 A -0.49 B 5.27	Trial 16	4.5 4.5 3.0
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.			
Adhesion	Visibly inspect component for obvious indications of adhesion loss.			

Additional Notes:

(Add additional pages as necessary)

	dft
(7)	2.5
	2.6
	3.0
(8)	~~3.2~~
	5.5
	6.4
	6.1
(9)	2.7
	2.2
	2.3
(10)	5.5
	4.5
	5.5

Field Service Evaluation Checklist

Component ID: PWA-14408

Component Name: AFT Engine Yoke

Serial Number: 800-242

Date of Inspection: 17 July 2008

Reason For Inspection: Second Field Evaluation

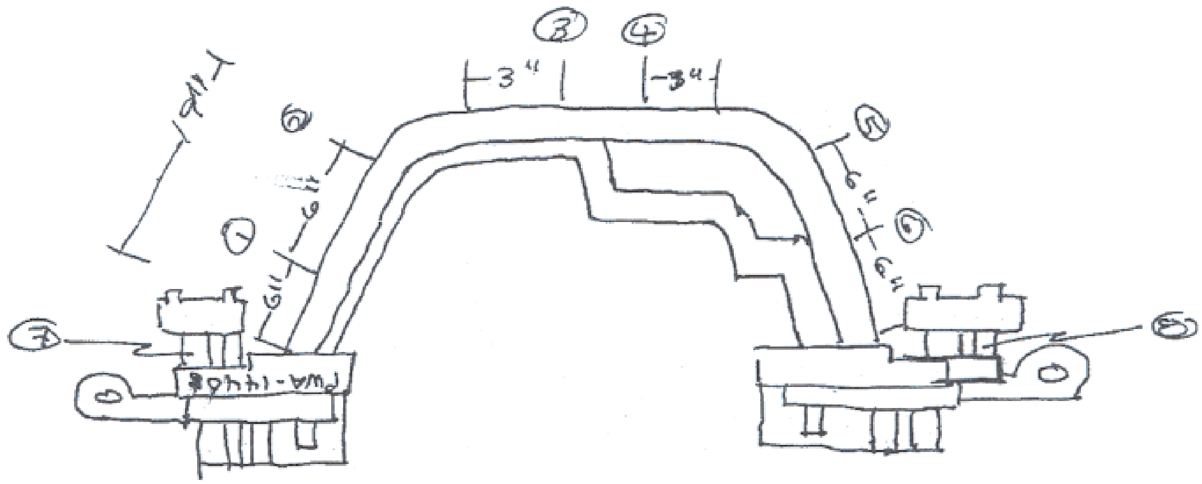
Name of Inspector: Steve Finley

Location of Inspection: FRC NW 900 Div

Time of Inspection: ______

NOTE: All Readings Taken From Side Showing P/N

Data is the result of the average of three readings per location



9, 10 reverse side from 7, 8

Reading	Data		Comments
1.	60° NT	L* 92.2	
	85° NT	a* −0.94	
	DFT NT 3.6	b* 2.50	
		Trail 50	
2	60° NT	L* 94.03	
	85° NT	a* −0.86	
	DFT NT 3.7	b* 3.45	
		Trail 51	
3	60° NT	L* 93.28	
	85° NT	a* −0.77	
	DFT NT 4.5	b* 3.64	
		Trail 52	
4	60° NT	L* 94.61	
	85° NT	a* −0.51	
	DFT NT 6.1	b* 4.34	
		Trail 53	
5	60° NT	L* 94.4	
	85° NT	a* −0.34	
	DFT NT 4.6	b* 4.66	
		Trail 54	
6	60° NT	L* 93.7	
	85° NT	a* −0.20	
	DFT NT 8.1	b* 4.79	
		Trail 55	

7	60° 19.9 L* NT 85° 32.4 a* NT DFT 1.22 b* NT Trail NT	
8	60° 36.7 L* NT 85° 47.1 a* NT DFT 2.3 b* NT 2.51 Trail	
9	60° 22.6 L* NT 85° 18.8 a* NT DFT 4.88 b* NT Trail NT	
10	60° 42.0 L* NT 85° 33.0 a* NT DFT 4.08 b* NT Trail NT	

Field Service Evaluation Checklist #2

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes: Minor scratches
no significant corrosion except around bolts
very minor scraping.

(Add additional pages as necessary)

Table 91. J52 Aft Engine Yoke (SN: P9H516) Raw Data

Field Service Evaluation Checklist #1

Component ID: PWA-14408

Component Name: Aft Engine Yoke

Serial Number: P9H516

Date of Inspection: 1/30

Name of Inspector: SF

Location of Inspection: FRC NW 900 DIV

Time of Inspection: 12:29

Part arrival in Paint Shop, Date, Time: N/A

Earliest Date, Time when part could depart: N/A

Preheat time (if any): 60, TYP. minutes

Time to apply powder on component: 5, TYP. minutes

Amount of powder applied (pounds): N/A

Complete following if doing a two pass coating

1st Bake (if applicable): 30 TYP. minutes

Second powder application (if applicable): N/A minutes

Amount of powder in second coat (if applicable)(pounds): N/A

Complete the following for all applications

Full bake time: 30 TYP. minutes

Time from bake end to de-mask start (cool down time): 20 TYP. minutes

Field Service Evaluation Checklist #2

Component ID: PWA-14408

Component Name: Aft Engine Yoke

Serial Number: P9H516

Date of Inspection: 1/30

Name of Inspector: SF

Location of Inspection: FRC NW 900 Div

Time of Inspection: 12:40

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	concave surface #7 d.f.t.
Gloss #~~1~~ 7	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 44.2 85° 26.3 5.0 5.2 6.5
Gloss #~~2~~ 8	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 45.9 85° 54.5 4.9 4.0 4.4
Gloss #~~3~~ 9	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 50.4 85° 55.0 7.0 5.3 7.0
Gloss #1 0	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 46.8 85° 55.2 6.5 6.4 5.5
Gloss #5	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	
Gloss #6	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	

Field Service Evaluation Checklist (Continued)

Component ID: PWA-14408

Component Name: Aft Engine Yoke

Serial Number: P9H516

Performance Criteria	Instructions	Results and Observations	d.f.t
Color #1	Using attached drawing, determine location to take measurement.	L 94.23 A -0.85 B 4.96 Trial 29	4.0 3.7 3.1
Color #2	Using attached drawing, determine location to take measurement.	L 95.02 A -0.74 B 5.40 Trial 30	4.3 4.3 4.2
Color #3	Using attached drawing, determine location to take measurement.	L 93.25 A -0.92 B 5.21 Trial 31	2.7 3.0 2.8
Color #4	Using attached drawing, determine location to take measurement.	L 94.73 A -1.07 B 5.81 Trial 32	3.5 3.6 3.6
Color #5	Using attached drawing, determine location to take measurement.	L 94.77 A -0.50 B 5.81 Trial 33	5.4 6.0 5.3
Color #6	Using attached drawing, determine location to take measurement.	L 93.85 A -0.79 B 5.16 Trial 34	3.7 4.0 5.2
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.		
Adhesion	Visibly inspect component for obvious indications of adhesion loss.		

Additional Notes: ____________________

(Add additional pages as necessary)

Field Service Evaluation Checklist

Component ID: PWA-14408

Component Name: AFT Engine Yoke

Serial Number: P9H516

Date of Inspection: 17 July 2008

Reason For Inspection: Second Field Evaluation

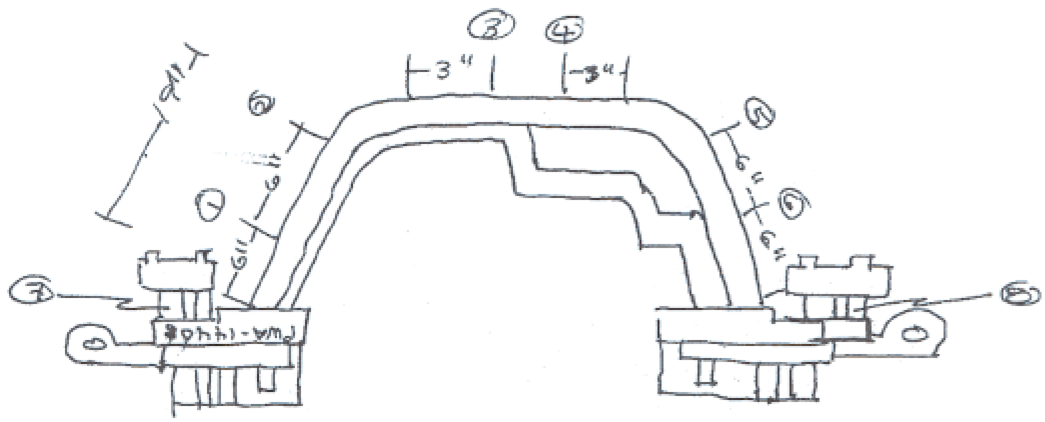
Name of Inspector: Steve Finley

Location of Inspection: FRC NW 900 Div

Time of Inspection:____________________

NOTE: All Readings Taken From Side Showing P/N

Data is the result of the average of three readings per location



9, 10 reverse side from 7, 8

Reading	Data		Comments
1	60° NT	L* 94.4	
	85° NT	a* -.60	
	DFT NT	b* 4.17	
		Trail 38	
2	60° NT	L* 95.69	
	85° NT	a* -0.60	
	DFT NT	b* 4.40	
		Trail 39	
3	60° NT	L* 92.65	datapoints measured on other side, Component upside down and paint worn off -
	85° NT	a* -0.75	
	DFT NT	b* 3.11	
		Trail 40	
4	60° NT	L* 89.08	
	85° NT	a* -0.64	
	DFT NT	b* 3.94	
		Trail 41	
5	60° NT	L* 92.48	
	85° NT	a* -0.62	
	DFT NT	b* 4.20	
		Trail 42	
6	60° NT	L* 92.05	
	85° NT	a* -0.83	
	DFT NT	b* 3.17	
		Trail 43	

7	60° ~~16.2~~ 22.5 85° ~~27.1~~ 21.8 DFT 4.09	L* NT a* NT b* NT Trail NT	Concave surface
8	60° ~~35.8~~ 35.8 85° 58.5 DFT 2.63	L* NT a* NT b* NT Trail	
9	60° 22.5 85° 33.9 DFT 4.48	L* NT a* NT b* NT Trail NT	
10	60° ~~[illegible]~~ 36.7 85° ~~[illegible]~~ 37.4 DFT ~~2.63~~ 7.61	L* NT a* NT b* NT Trail NT	

Field Service Evaluation Checklist

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes: Most used condition of the three.

(Add additional pages as necessary)

Table 92. J52 Forward Engine Yoke (SN: P9HA08) Raw Data

Field Service Evaluation Checklist #1

Component ID: PWA - 9963A , TEC GMBU

Component Name: Forward Engine Yoke

Serial Number: P9HA08

ALL READINGS TAKEN FROM SIDE SHOWING P/N

Date of Inspection: 1/30

Name of Inspector: SF

Location of Inspection: FRC NW 900 DIV.

Time of Inspection: 10.30

Part arrival in Paint Shop, Date, Time: N/A

Earliest Date, Time when part could depart: N/A

Preheat time (if any): 60, TYP. minutes

Time to apply powder on component: 5, TYP. minutes

Amount of powder applied (pounds): N/A

Complete following if doing a two pass coating

1st Bake (if applicable): 30, TYP. minutes

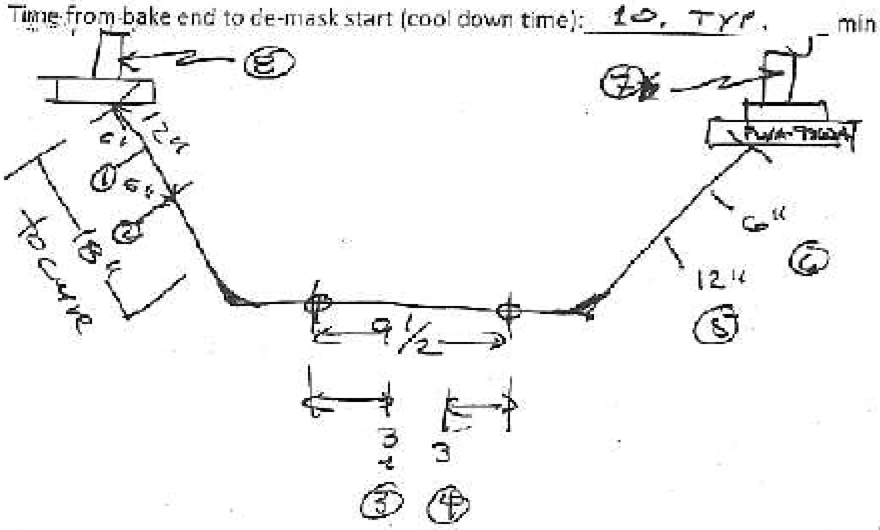
Second powder application (if applicable): N/A minutes

Amount of powder in second coat (if applicable)(pounds): ______

Complete the following for all applications

Full bake time: 30, TYP. minutes

Time from bake end to de-mask start (cool down time): 10, TYP. minutes



Data points 9 and 10 same as 7 and 8 on other side

Field Service Evaluation Checklist #2

Component ID: PWA-9962A

Component Name: Forward Engine Yoke

Serial Number: P9HA08

Date of Inspection: 1/30

Name of Inspector: ~~1030~~ ~~CSM~~ SF

Location of Inspection: FRC NW 900 DIV

Time of Inspection: 10.30

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Gloss #1 60° 0.2 85° 83.9	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	
Gloss #2 60° 0.2 85° 82.1	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	
Gloss #3 60° 85°	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	
Gloss #4	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	
Gloss #5	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	
Gloss #6	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	

Field Service Evaluation Checklist (Continued)

Component ID: PWA-9963A
Component Name: Forward Engine Yoke
Serial Number: P94A08

Performance Criteria	Instructions	Results and Observations (avg. of 3)	d.f.+
Color #1	Using attached drawing, determine location to take measurement.	L 93.56 A -0.90 B 4.57 Trial 5	3.6 3.3 3.5
Color #2	Using attached drawing, determine location to take measurement.	L 94.12 A -0.96 B 4.55 Trial 6	3.6 3.2 4.2
Color #3	Using attached drawing, determine location to take measurement.	L 94.18 A -0.86 B 5.14 Trial 7	4.0 3.8 3.9
Color #4	Using attached drawing, determine location to take measurement.	L 94.29 A -0.94 B 4.96 Trial 8	3.3 3.4 3.6
Color #5	Using attached drawing, determine location to take measurement.	L 94.93 A -0.88 B 4.68 Trial 9	3.7 3.9 3.0
Color #6	Using attached drawing, determine location to take measurement.	L 93.42 A -0.59 B 5.21 Trial 10	4.6 4.7 5.1
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.		
Adhesion	Visibly inspect component for obvious indications of adhesion loss.		

Additional Notes:

(Add additional pages as necessary)

Par 85285, gloss should be minimum 90
24712. 90 gloss min. also!

Field Service Evaluation Checklist

Component ID: PWA-9963A TEC GMBU

Component Name: Forward Engine Yoke

Serial Number: P9HA08

Date of Inspection: 17 July 2008

Reason For Inspection: Second Field Evaluation

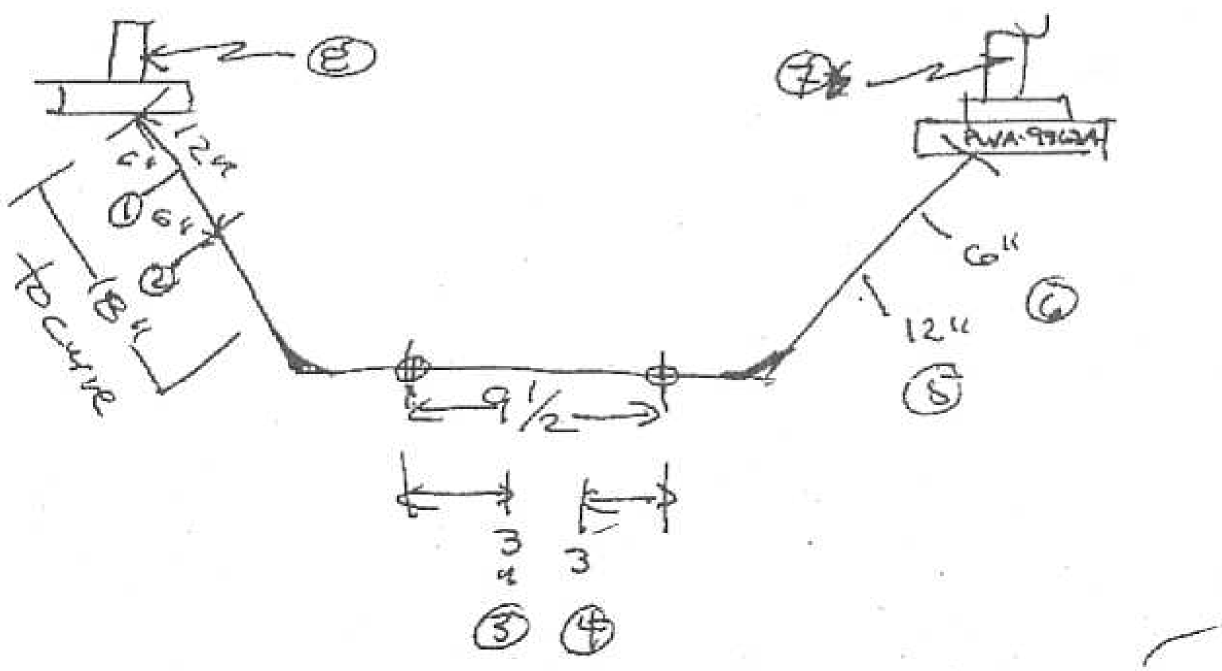
Name of Inspector: Steve Finley

Location of Inspection: FRC NW 900 Div

Time of Inspection:

NOTE: All Readings Taken From Side Showing P/N

Data is the result of the average of three readings per location



Data points 9 and 10 same as 7 and 8 on other side

Reading	Data	Comments
1	60° 85° DFT 4.2 L* 94.43 a* -0.76 b* 3.52 Trail 44	
2	60° 85° DFT 2.4 L* 93.71 a* -0.92 b* 3.12 Trail 45	
3	60° NT 85° NT DFT NT 3.9 L* 90.74 a* -0.86 b* 3.52 Trail 46	
4	60° NT 85° NT DFT NT 4.6 L* 93.27 a* -0.72 b* 4.04 Trail 47	
5	60° NT 85° NT DFT NT 3.3 L* 93.98 a* -0.94 b* 3.91 Trail 48	
6	60° NT 85° NT DFT NT 2.9 L* 93.23 a* -1.11 b* 3.37 Trail 49	

7	60° 54.6 L* NT 85° 70.1 a* NT DFT 3.30 b* NT Trail NT	
8	60° 45.8 L* NT 85° 76.5 a* NT DFT 3.33 b* NT Trail	
9	60° 60.4 L* NT 85° 86.0 a* NT DFT 5.38 b* NT Trail NT	
10	60° 39.0 L* NT 85° 51.9 a* NT DFT 5.31 b* NT Trail NT	

Field Service Evaluation Checklist #2

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes: overspray still on threads – very minimal usage?

(Add additional pages as necessary)

Table 93. Engine Support Adapter (SN: 41A364) Raw Data

Instructions for Use.

1. At first evaluation, fill out Field Service Evaluation Checklist #1 to include the time in terms of process time (how long was component in the paint shop), actual labor hours while part was being coated, and amount of powder used (estimated).

2. Before taking measurements for Field Service Evaluation Checklist #2, obtain a drawing, create a hand drawing, or take measurements from a common datum point to the points on the component where the test measurements will/are made. This drawing or other documentation should remain with both of these checklists so that it is available for follow on sampling.

P/N PWA14003

engine adapter, S/N 41A364, owned by W/C 350

0833 – turn on fans

need scale to measure for actual coating used

1 hr – 1.5 hr to preheat

0900 – spraying begins

hopper overfilled

0903 – ends, to cure

no "two bake" process

0932 – remove

cool to touch w/in 10 min

must heat to remove stripper from inside of metal parts. Metal is porous.

---

glovebox unit not installed yet.

2nd CLASS PETTY
GARY JAECKIN

PWA 14003 **Field Service Evaluation Checklist #1**

Component ID:

Component Name: ENGINE SUPPORT ADAPTER 3 PARTS

Serial Number: 41A364 WORK CENTER 450

Date of Inspection: 30 JAN 08

Name of Inspector: STEVE FINLEY

Location of Inspection: WHIDBEY ISLAND NAS

Time of Inspection: 0850

Part arrival in Paint Shop, Date, Time:

Earliest Date, Time when part could depart:

Preheat time (if any): ≈ 1 HR

Time to apply powder on component: 2 MIN PART I .30 2nd TWO PARTS minutes

Amount of powder applied (pounds):

Complete following if doing a two pass coating

1st Bake (if applicable): N/A minutes

Second powder application (if applicable): N/A minutes

Amount of powder in second coat (if applicable)(pounds):

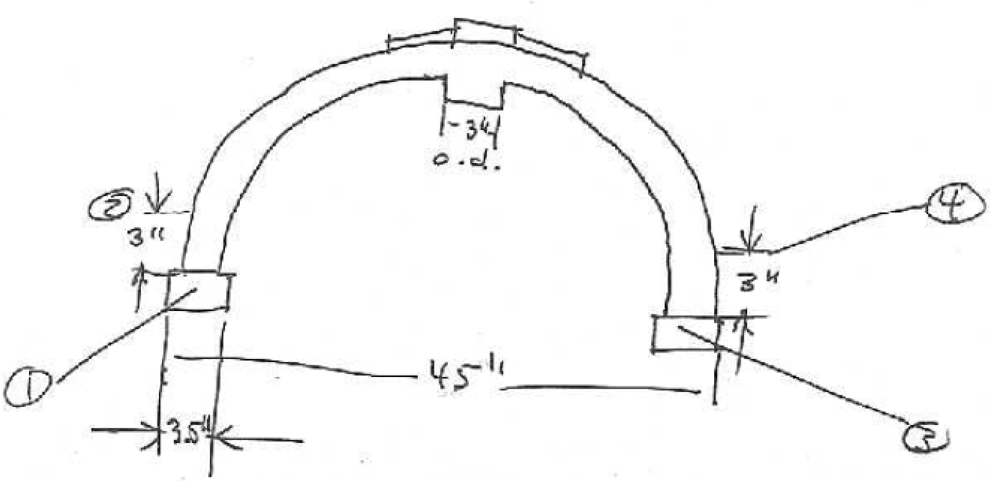
Complete the following for all applications

Full bake time: 0901 0931 = 30 MIN minutes

Time from bake end to de-mask start (cool down time): 0931 minutes

PULLED PLUGS @ 0958
REMOVED TAPE

TOTAL TIME 1.5 hrs.



5, 6, 7, 8 reverse side

Field Service Evaluation Checklist (Continued)

Component ID: PWA 14008
Component Name: Engine Support Adapter
Serial Number: 91A364

Performance Criteria	Instructions	Results and Observations
Color #1	Using attached drawing, determine location to take measurement.	L 95.39 A -1.01 B 2.42 Trial 43
Color #2	Using attached drawing, determine location to take measurement.	L 94.14 A -1.02 B 2.31 Trial 44
Color #3	Using attached drawing, determine location to take measurement.	L 94.91 A -1.09 B 1.82 Trial 45
Color #4	Using attached drawing, determine location to take measurement.	L 92.77 A -1.09 B 1.71 Trial 46
Color #5	Using attached drawing, determine location to take measurement.	L 95.70 A -0.96 B 2.84 Trial 47
Color #6	Using attached drawing, determine location to take measurement.	L 93.07 A -1.00 B 2.30 Trial 48
Corrosion #7	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	L 93.83 A -1.27 B 0.85 Trial 49
Adhesion #8	Visibly inspect component for obvious indications of adhesion loss.	L 93.42 A -1.14 B 1.20 Trial 50

Additional Notes:

(Add additional pages as necessary)

Field Service Evaluation Checklist #2

Component ID: PWA 14003

Component Name: Engine Support Adapter

Serial Number: 41A364 Work Center 45C

Date of Inspection: 1/30

Name of Inspector: SF

Location of Inspection: FRC NW 900 Div

Time of Inspection: 0850

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	d.f.t.
Gloss #1	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 73.1 85° 82.1 3.4 3.4 4.2
Gloss #2	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 53.1 85° 62.4 3.7 4.1 3.3
Gloss #3	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 56.7 85° 67.1 3.4 2.8 2.9
Gloss #4	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 41.2 85° 51.7 can see light – not flat 2.9 3.0 3.7
Gloss #5	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 74.1 85° 84.3 4.1 5.0 4.2
Gloss #6	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 37.7 85° 51.5 5.0 3.5 4.8

			e.f.b.
(7)	60°	60.6	2.3
	85°	67.2	2.4
			1.95
(8)	60°	44.5	2.4
	85°	48.1	2.3
			2.5

Field Service Evaluation Checklist

Component ID: PWA-14403

Component Name: Engine Support Adapter

Serial Number: 41A364 WC 450

Date of Inspection: 17 July 2008

Reason For Inspection: Second Field Evaluation

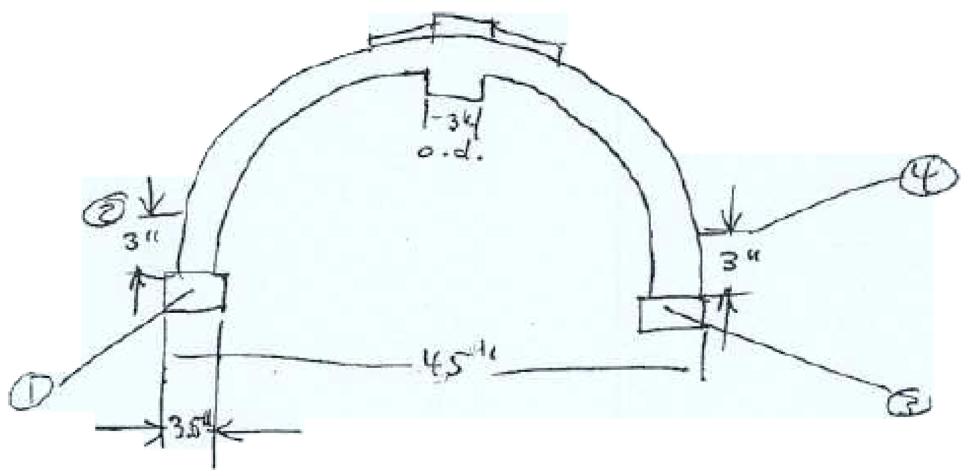
Name of Inspector: Steve Finley

Location of Inspection: FRC NW 900 Div

Time of Inspection:

Stripped and sent to DRMO because spinning part failed. collar threads stripped

coating performance not part of failure



5, 6, 7, 8 reverse side

Table 94. J52 Aft Engine Yoke (SN: P9H218) Raw Data

Field Service Evaluation Checklist #1

Component ID: PWA-14408

Component Name: Aft Engine Yoke

Serial Number: P9H218

Date of Inspection: 1/30

Name of Inspector: SF

Location of Inspection: FRC NW 900 DIV.

Time of Inspection: 12:45

Part arrival in Paint Shop, Date, Time: N/A

Earliest Date, Time when part could depart: N/A

Preheat time (if any): 60, TYP. minutes

Time to apply powder on component: 5, TYP. minutes

Amount of powder applied (pounds): N/A

Complete following if doing a two pass coating

1st Bake (if applicable): 30 TYP. minutes

Second powder application (if applicable): N/A minutes

Amount of powder in second coat (if applicable)(pounds): N/A

Complete the following for all applications

Full bake time: 30 TYP. minutes

Time from bake end to de-mask start (cool down time): 10 TYP. minutes

Field Service Evaluation Checklist #2

Component ID: PWA - 14408

Component Name: Aft Engine Yoke.

Serial Number: P9H 218

Date of Inspection: 1/30

Name of Inspector: SF

Location of Inspection: FRC NW 900 DIV.

Time of Inspection: 12:45

Performance Criteria	Instructions	Results and Observations	
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects		d.f.
Gloss #7	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 81.2 85° ~~[illegible]~~ .90.7	4.9 4.8 5.?
Gloss #8	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 84.2 85° 86.8	4.7 5.0 6.1
Gloss #9	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 86.6 85° 92.3	4.3 4.2 4.7
Gloss #10	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 86.8 85° 97.7	5.3 6.4 6.1
Gloss #5	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.		
Gloss #6	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.		

Field Service Evaluation Checklist (Continued)

Component ID: PWA-14408

Component Name: Aft Engine Yoke

Serial Number: P9H218

Performance Criteria	Instructions	Results and Observations	d.f.t
Color #1	Using attached drawing, determine location to take measurement.	L 93.73 A -0.74 B 3.05 Trial 17	6.5 7.0 7.2
Color #2	Using attached drawing, determine location to take measurement.	L 95.09 A -0.99 B 2.07 Trial 18	3.9 4.0 4.3
Color #3	Using attached drawing, determine location to take measurement.	L 95.69 A -0.99 B 3.06 Trial 19	5.4 4.9 5.0
Color #4	Using attached drawing, determine location to take measurement.	L 93.99 A -1.10 B 3.55 Trial 20	6.7 6.2 6.0
Color #5	Using attached drawing, determine location to take measurement.	L 95.15 A -0.73 B 2.87 Trial 21	7.0 6.8 8.0
Color #6	Using attached drawing, determine location to take measurement.	L 95.15 A -0.81 B 3.10 Trial 22	5.4 5.8 6.4
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.		
Adhesion	Visibly inspect component for obvious indications of adhesion loss.		

Additional Notes:

(Add additional pages as necessary)

Table 95. Pod Cradle Assembly (SN: PC5043) Raw Data

Field Service Evaluation Checklist #1

Component ID: 4920-00-483-1837

Component Name: POD CRADLE, P/N 1128SME40800-1

Serial Number: PC5043

Date of Inspection: 1/30

Name of Inspector: SF

Location of Inspection: FRC 900 DIV

Time of Inspection: 1300

Part arrival in Paint Shop, Date, Time: N/A

Earliest Date, Time when part could depart: N/A

Preheat time (if any): 90, TYP. minutes

Time to apply powder on component: 5, TYP. minutes

Amount of powder applied (pounds): N/A

Complete following if doing a two pass coating

1st Bake (if applicable): 30, TYP. minutes

Second powder application (if applicable): N/A minutes

Amount of powder in second coat (if applicable)(pounds): N/A

Complete the following for all applications

Full bake time: 30, TYP. minutes

Time from bake end to de-mask start (cool down time): 10, TYP. minutes

Field Service Evaluation Checklist #2

Component ID:
Component Name: Pod Cradle
Serial Number: PC5043

Date of Inspection: 1/30
Name of Inspector: SF
Location of Inspection: FRC - 900 DIV
Time of Inspection: 12.37

Performance Criteria	Instructions	Results and Observations d.f.t.
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Gloss #1	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 64.4 85° 66.2 3.7 3.2 3.7
Gloss #2	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 61.4 85° 64.8 5.2 5.1 4.9
Gloss #3	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 58.7 85° 62.6 4.4 3.6 3.9
Gloss #4	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 54.7 85° 60.3 3.7 3.3 3.5
Gloss #5	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 72.7 85° 79.4 7.2 5.3 4.4
Gloss #6	60 degree gloss meter readings. Use attached drawing to determine location to take measurement.	60° 76.6 85° 75.6 6.1 6.8 6.6

Field Service Evaluation Checklist (Continued)

Component ID: 4920-00-483-1837
Component Name: Pod Cradle,
Serial Number: PGS043

Performance Criteria	Instructions	Results and Observations
Color #1	Using attached drawing, determine location to take measurement.	L 95.11 A -1.05 B 2.46 Trial 35
Color #2	Using attached drawing, determine location to take measurement.	L 95.31 A -1.00 B 2.89 Trial 36
Color #3	Using attached drawing, determine location to take measurement.	L 94.41 A -1.07 B 2.58 Trial 37
Color #4	Using attached drawing, determine location to take measurement.	L 94.08 A -1.03 B 3.18 Trial 38
Color #5	Using attached drawing, determine location to take measurement.	L 96.34 A -0.88 B 3.41 Trial 39
Color #6	Using attached drawing, determine location to take measurement.	L 96.24 A -0.95 B 3.21 Trial 40
Corrosion #7	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	L 96.36 A -0.80 B 3.75 Trial 41
Adhesion #8	Visibly inspect component for obvious indications of adhesion loss.	L 96.41 A -0.71 B 3.81 Trial 42

Additional Notes:

(Add additional pages as necessary)

			d.f.t.
(7)	60°	79.5	7.0
	85°	74.8	7.7
			7.0
(8)	60°	83.6	9.4
	85°	76.5	9.6
			9.4

Table 96. PON-6 Engine Pre-Oiler (SN: P9HV20) Raw Data

Field Service Evaluation Checklist #1

Component ID: PON-6
Component Name: Engine Pre-Oiler
Serial Number: P9HV20

Date of Inspection: 8/11/09
Name of Inspector: S. FINLEY/C. MAHENDRA
Location of Inspection: FRC-NW
Time of Inspection: 10.38

Part arrival in Paint Shop, Date, Time:________
Earliest Date, Time when part could depart:________
Preheat time (if any):________ minutes
Time to apply powder on component:________ minutes
Amount of powder applied (pounds):________

Complete following if doing a two pass coating

1st Bake (if applicable):________ minutes
Second powder application (if applicable):________ minutes
Amount of powder in second coat (if applicable)(pounds):________

Complete the following for all applications

Full bake time:________ minutes

Time from bake end to de-mask start (cool down time):________ minutes

Mechanical wear and tear only

Field Service Evaluation Checklist (Continued)

Component ID:____

Component Name:______________________________________

Serial Number:_______________________________________

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes:_______________________________________

(Add additional pages as necessary)

Field Service Evaluation Checklist #1

Component ID: PON-6

Component Name: PON-6 Engine Pre-Oiler.

Serial Number: P9HV20 ✓

Date of Inspection: 4/21/09

Name of Inspector: Steve Finley

Location of Inspection: FRC-NW

Time of Inspection: 11.20

Part arrival in Paint Shop, Date, Time: 4/9/09

Earliest Date, Time when part could depart: 4/9/09

Preheat time (if any): 30 minutes

Time to apply powder on component: 15 minutes

Amount of powder applied (pounds): unknown

Complete following if doing a two pass coating

1st Bake (if applicable): ______ minutes

Second powder application (if applicable): ______ minutes

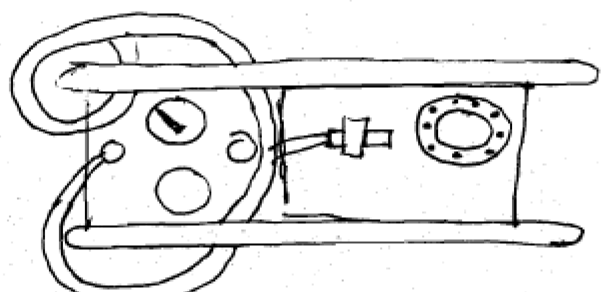
Amount of powder in second coat (if applicable)(pounds): ______

Complete the following for all applications

Full bake time: ______ minutes

Time from bake end to de-mask start (cool down time): ______ minutes

Visual inspection only, cannot do the actual measurements



Field Service Evaluation Checklist (Continued)

Component ID:____

Component Name:______________________________________

Serial Number:____

Performance Criteria	Instructions	Results and Observations
Appearance	Uniform smooth surface free of runs, sags, bubbles, or other defects	No Faraday Cage effect, no orange peel
Corrosion	Look for undercutting, pitting, bubbling. Determine if any repairs have occurred.	
Adhesion	Visibly inspect component for obvious indications of adhesion loss.	

Additional Notes:____

(Add additional pages as necessary)

Table 97. Full FSE Color Results by FSE Component

Nitrogen Servicing Cart, SN: NRR073

Date	Location	L	a	b	Trial
06 March 2008	1	94.60	-0.60	4.68	32
	2	94.81	-0.50	5.06	33
	3	95.39	-0.65	4.00	34
	4	94.48	-0.75	3.88	35
	5	92.94	-0.83	4.10	36
	6	94.49	-0.79	3.71	37
	7	92.95	-0.95	3.25	31
	8	92.76	-0.78	3.86	30
	9	93.81	-0.77	4.53	21
	10	92.45	-0.97	3.29	22
	11	NT	NT	NT	NT
	12	93.83	-0.50	5.34	27
	13	94.28	-0.33	5.52	26
	14	94.97	-0.30	5.53	25
	15	95.66	-0.33	4.86	24
	16	NT	NT	NT	NT
	17	95.02	-0.59	4.73	20
	18	95.00	-0.60	4.39	23
	19	93.74	-0.46	5.06	28
	20	94.68	-0.64	4.37	29
	Mean (μ)	**94.21**	**-0.63**	**4.45**	
	Standard Deviation (σ)	**0.94**	**0.20**	**0.71**	
03 February 2009	1	92.40	-0.16	8.21	2
	2	91.18	-0.26	8.18	3
	3	89.54	-0.35	7.76	4
	4	87.82	-0.25	7.99	5
	5	88.34	-0.44	7.57	6
	6	89.87	-0.43	7.22	7
	7	91.12	-0.59	5.25	8
	8	89.99	-0.72	4.86	9
	9	92.60	-0.73	5.90	10

Date	Location	L	a	b	Trial
	10	91.24	-0.53	5.95	11
	11	NT	NT	NT	NT
	12	90.01	-0.09	6.66	12
	13	92.70	-0.28	7.01	13
	14	92.92	-0.16	7.24	14
	15	92.66	-0.13	6.34	15
	16	NT	NT	NT	NT
	17	90.20	-0.04	6.68	16
	18	89.37	-0.08	7.12	17
	19	90.09	-0.15	6.35	18
	20	89.36	-0.25	6.97	19
	Mean (μ)	**90.63**	**-0.31**	**6.85**	
	Standard Deviation (σ)	**1.55**	**0.22**	**0.95**	
04 November 2009	1	92.21	-0.22	9.14	3
	2	88.29	0.3	11.13	4
	3	86.81	0.5	13.85	5
	4	87.42	0.15	11.77	6
	5	NT	NT	NT	NT
	6	NT	NT	NT	NT
	7	87.82	0.06	11.4	7
	8	74.33	0.21	9.54	8
	9	88.7	0	10.27	9
	10	87.62	0.16	10.98	10
	11	NT	NT	NT	NT
	12	85.87	0.47	9.06	11
	13	88.16	0.23	9.73	12
	14	87.62	0.49	10.59	13
	15	91.51	0.05	6.72	14
	16	NT	NT	NT	NT
	17	92.42	-0.09	7.16	15
	18	91.39	-0.07	6.83	16
	19	88.95	0.12	8.36	17

Date	Location	L	a	b	Trial
	20	NT	NT	NT	NT
	Mean (μ)	**87.94**	**0.16**	**9.77**	
	Standard Deviation (σ)	**4.28**	**0.22**	**1.99**	

NT = Not Taken

Nitrogen Servicing Cart, SN: NRR204

Date	Location	L	a	b	Trial
06 March 2008	1	93.88	-0.64	4.11	12
	2	94.48	-0.71	3.35	13
	3	94.78	-0.67	3.38	14
	4	93.99	-0.69	3.74	15
	5	94.28	-0.75	3.84	16
	6	94.16	-0.56	4.55	17
	7	94.55	-0.59	3.47	18
	8	94.74	-0.59	3.43	19
	9	95.00	-0.58	3.84	5
	10	95.35	0.65	3.01	6
	11	NT	NT	NT	NT
	12	92.56	-0.55	3.83	9
	13	92.01	-0.61	4.72	8
	14	93.66	-0.67	4.20	7
	15	93.54	-0.50	3.86	4
	16	NT	NT	NT	NT
	17	96.02	-0.69	2.86	2
	18	94.38	-0.61	3.79	3
	19	94.81	-0.72	2.98	10
	20	93.15	-0.42	4.01	11
	Mean (μ)	**94.19**	**-0.55**	**3.72**	
	Standard Deviation (σ)	**0.97**	**0.31**	**0.51**	
03 February	1	90.31	-0.28	9.08	23
	2	90.49	-0.40	9.12	24

Date	Location	L	a	b	Trial
2009	3	90.45	-0.33	8.95	25
	4	88.74	-0.28	8.84	26
	5	89.28	-0.28	9.73	27
	6	83.20	0.46	12.46	28
	7	92.18	-0.59	5.90	29
	8	88.28	-0.19	6.77	30
	9	93.24	-0.46	5.96	31
	10	93.53	-0.59	5.59	32
	11	NT	NT	NT	NT
	12	87.73	-0.11	7.21	33
	13	90.34	-0.73	6.73	34
	14	92.25	-0.70	6.50	35
	15	94.41	-0.75	4.84	36
	16	NT	NT	NT	NT
	17	89.45	-0.43	6.70	37
	18	90.50	-0.41	6.74	38
	19	89.25	-0.23	7.60	39
	20	90.75	-0.26	7.28	40
	Mean (μ)	**90.24**	**-0.36**	**7.56**	
	Standard Deviation (σ)	**2.54**	**0.28**	**1.84**	

NT = Not Taken

J52 Aft Engine Yoke, SN: P9H513

Date	Location	L	a	b	Trial
30 January 2008	1	89.37	-1.13	3.52	23
	2	88.08	-1.29	2.53	24
	3	93.12	-1.06	4.82	25
	4	93.96	-0.96	4.64	26
	5	93.97	-0.89	4.51	27
	6	94.33	-1.03	4.08	28
	7	NT	NT	NT	NT
	8	NT	NT	NT	NT
	9	NT	NT	NT	NT

Date	Location	L	a	b	Trial
	10	NT	NT	NT	NT
	11	NT	NT	NT	NT
	12	NT	NT	NT	NT
	Mean (μ)	**92.14**	**-1.06**	**4.02**	
	Standard Deviation (σ)	**2.70**	**0.14**	**0.86**	
17 July 2008	1	93.06	-0.44	3.55	56
	2	90.33	-0.86	1.80	57
	3	90.60	-0.79	2.42	58
	4	90.96	-0.58	2.77	59
	5	92.94	-0.56	3.08	60
	6	93.83	-0.68	2.68	61
	7	NT	NT	NT	NT
	8	NT	NT	NT	NT
	9	NT	NT	NT	NT
	10	NT	NT	NT	NT
	11	NT	NT	NT	NT
	12	NT	NT	NT	NT
	Mean (μ)	**91.95**	**-0.65**	**2.72**	
	Standard Deviation (σ)	**1.49**	**0.16**	**0.59**	
27 January 2009	1	94.48	-0.69	2.58	NT
	2	93.12	-0.85	1.88	NT
	3	90.38	-0.64	2.9	NT
	4	91.47	-0.68	2.48	NT
	5	93.29	-0.57	2.87	NT
	6	93.26	-0.68	2.52	NT
	7	NT	NT	NT	NT
	8	NT	NT	NT	NT
	9	NT	NT	NT	NT
	10	NT	NT	NT	NT
	11	95.37	-0.45	3.42	NT
	12	92.96	-0.4	3.98	NT

Date	Location	L	a	b	Trial
	Mean (μ)	**93.04**	**-0.62**	**2.83**	
	Standard Deviation (σ)	**1.57**	**0.14**	**0.64**	

NT = Not Taken

C-130 Nose Landing Gear Forward Door, AC: 92-1534

Date	Location	L	a	b	E
May 2008	1	66.23	-4.92	1.48	66.4
	2	66.10	-4.86	1.41	66.3
	3	66.00	-4.78	1.38	66.2
	4	66.00	-4.79	1.46	66.2
	Mean (μ)	**66.08**	**-4.84**	**1.43**	
	Standard Deviation* (σ)	**0.11**	**0.07**	**0.05**	
July 2009	1	66.25	-4.95	1.08	66.4
	2	66.32	-4.95	1.06	66.5
	3	66.02	-4.99	1.09	66.2
	4	66.20	-4.94	1.19	66.4
	Mean (μ)	**66.20**	**-4.96**	**1.11**	
	Standard Deviation* (σ)	**0.13**	**0.02**	**0.06**	

* Calculations are questionable due to very small sample size

C-130 Nose Landing Gear Aft Door, AC: 92-1534

Date	Location	L	a	b	E
May 2008	1	66.06	-4.87	1.35	66.3
	2	66.16	-4.79	1.34	66.3
	3	66.13	-4.79	1.76	66.3
	Mean (μ)	**66.12**	**-4.82**	**1.48**	
	Standard Deviation* (σ)	**0.05**	**0.05**	**0.24**	
July	1	66.02	-4.78	1.02	66.2

Date	Location	L	a	b	E
2009	2	ANA	ANA	ANA	ANA
	3	66.25	-4.70	1.10	66.4
	Mean (μ)	**66.14**	**-4.74**	**1.06**	
	Standard Deviation* (σ)	**0.16**	**0.06**	**0.06**	

ANA = Area Not Accessible

* Calculations are questionable due to very small sample size

Table 98. Full FSE Gloss Results by FSE Component

Nitrogen Servicing Cart, SN: NRR073

Location	Angle	06 Mar 2008	03 Feb 2009	04 Nov 2009
1	60°	71.60	72.20	62.80
	85°	93.30	77.50	78.80
2	60°	75.30	74.20	63.20
	85°	93.00	84.00	81.90
3	60°	71.90	53.90	32.10
	85°	83.50	57.30	70.20
4	60°	70.40	53.90	24.80
	85°	79.80	73.30	45.70
5	60°	63.30	23.90	NT
	85°	71.60	39.00	NT
6	60°	52.20	55.90	NT
	85°	58.10	60.90	NT
7	60°	51.50	56.90	43.40
	85°	61.20	67.10	51.70
8	60°	60.30	53.50	14.20
	85°	66.30	63.40	38.40
9	60°	79.50	69.20	51.90
	85°	83.90	85.20	74.90
10	60°	54.50	70.80	26.70
	85°	67.70	83.90	48.00
11	60°	56.10	68.30	17.20
	85°	57.00	80.00	29.00
12	60°	74.30	63.10	26.20
	85°	76.50	82.60	37.40
13	60°	61.50	52.00	33.10
	85°	63.10	62.80	39.40
14	60°	78.00	66.60	36.40
	85°	85.80	81.90	58.00
15	60°	74.30	63.80	38.80
	85°	74.90	67.50	55.90
16	60°	59.20	39.50	33.30
	85°	61.20	56.70	51.40

Location	Angle	06 Mar 2008	03 Feb 2009	04 Nov 2009
17	60°	78.80	67.80	52.30
	85°	88.20	94.70	87.60
18	60°	78.60	59.30	50.20
	85°	82.60	82.50	87.20
19	60°	59.00	61.50	56.20
	85°	73.70	87.30	78.60
20	60°	75.20	48.60	28.70
	85°	90.10	66.40	65.30
Mean (μ)	**60°**	**67.28**	**58.75**	**38.42**
	85°	**75.58**	**72.70**	**59.97**
Standard Deviation (σ)	**60°**	**9.73**	**12.10**	**14.88**
	85°	**11.88**	**13.60**	**18.64**

NT = Not Taken

Nitrogen Servicing Cart, SN: NRR204

Location	Angle	06 Mar 2008	03 Feb 2009	04 Nov 2009
1	60°	68.60	52.10	46.10
	85°	75.40	51.50	79.40
2	60°	80.30	74.80	52.50
	85°	88.80	88.30	79.00
3	60°	75.90	73.30	46.40
	85°	86.40	84.00	78.30
4	60°	65.00	42.70	28.70
	85°	81.30	60.80	72.70
5	60°	71.60	58.30	38.90
	85°	86.10	76.30	70.20
6	60°	69.20	52.90	34.00
	85°	87.20	82.50	71.30
7	60°	64.40	84.50	59.70
	85°	76.10	90.90	88.20
8	60°	69.40	65.10	55.00
	85°	80.70	79.00	74.30
9	60°	66.50	78.30	44.10

Location	Angle	06 Mar 2008	03 Feb 2009	04 Nov 2009
	85°	81.60	91.90	86.20
10	60°	63.20	81.30	69.30
	85°	84.00	97.50	89.30
11	60°	63.30	44.10	57.60
	85°	65.40	57.60	81.50
12	60°	59.20	53.90	49.00
	85°	76.50	75.00	79.30
13	60°	54.50	54.10	50.90
	85°	64.40	66.20	56.90
14	60°	52.20	61.10	63.60
	85°	61.50	68.70	82.40
15	60°	62.00	28.20	69.40
	85°	76.40	43.10	87.80
16	60°	55.70	35.60	NT
	85°	79.10	41.70	NT
17	60°	65.20	40.50	42.00
	85°	69.00	65.70	75.10
18	60°	71.70	71.40	67.60
	85°	89.70	89.00	89.90
19	60°	58.90	60.20	56.50
	85°	69.30	74.60	86.98
20	60°	67.70	60.00	39.80
	85°	66.80	83.20	81.30
Mean (μ)	**60°**	**65.23**	**58.62**	**51.11**
	85°	**77.29**	**73.38**	**79.48**
Standard Deviation (σ)	**60°**	**7.06**	**15.61**	**11.81**
	85°	**8.72**	**16.18**	**8.25**

NT = Not Taken

J52 Aft Engine Yoke, SN: P9H513

Location	Angle	30 Jan 2008	17 Jul 2008	27 Jan 2009
1	60°	NT	NT	15.30
	85°	NT	NT	61.10

Location	Angle	30 Jan 2008	17 Jul 2008	27 Jan 2009
2	60°	NT	NT	39.00
	85°	NT	NT	43.60
3	60°	NT	NT	31.90
	85°	NT	NT	55.90
4	60°	NT	NT	41.00
	85°	NT	NT	55.80
5	60°	NT	NT	32.00
	85°	NT	NT	35.80
6	60°	NT	NT	39.50
	85°	NT	NT	72.50
7	60°	22.00	26.50	NT
	85°	20.20	37.90	NT
8	60°	37.00	23.90	NT
	85°	41.40	33.90	NT
9	60°	33.80	22.00	NT
	85°	41.10	38.30	NT
10	60°	41.60	16.80	NT
	85°	34.80	26.80	NT
11	60°	NT	NT	55.30
	85°	NT	NT	66.30
12	60°	NT	NT	55.70
	85°	NT	NT	75.40
Mean (μ)	**60°**	**33.60**	**22.30**	**38.71**
	85°	**34.38**	**34.23**	**58.30**
Standard Deviation (σ)	**60°**	**8.37**	**4.10**	**13.14**
	85°	**9.93**	**5.33**	**13.63**

NT = Not Taken

C-130 Nose Landing Gear Forward Door, AC: 92-1534

Location	Angle	May 2008	July 2009
1	60°	43.5	42.0
	85°	27.2	28.0
2	60°	34.4	34.0

Location	Angle	May 2008	July 2009
	85°	20.4	20.0
3	60°	35.3	NT
	85°	25.3	NT
4	60°	48.3	40.0
	85°	29.8	32.0
5	60°	30.9	35.0
	85°	20.0	24.0
6	60°	22.7	NT
	85°	14.7	NT
7	60°	37.8	35.0
	85°	25.1	27.0
8	60°	38.7	36.0
	85°	19.0	25.0
9	60°	25.0	32.0
	85°	12.8	23.0
Mean (μ)	**60°**	**35.18**	**36.29**
	85°	**21.59**	**25.57**
Standard Deviation (σ)	**60°**	**8.21**	**3.50**
	85°	**5.70**	**3.87**

NT = Not Taken

C-130 Nose Landing Gear Aft Door, AC: 92-1534

Location	Angle	May 2008	July 2009
1	60°	53.0	53.0
	85°	40.2	40.2
2	60°	45.6	45.6
	85°	33.5	33.5
3	60°	37.6	ANA
	85°	32.6	ANA
4	60°	44.5	ANA
	85°	34.2	ANA
5	60°	34.3	34.3
	85°	26.3	26.3

Location	Angle	May 2008	July 2009
6	60°	41.1	41.1
	85°	31.1	31.1
Mean (μ)	**60°**	**42.68**	**43.50**
	85°	**32.98**	**32.78**
Standard Deviation* (σ)	**60°**	**6.59**	**7.85**
	85°	**4.52**	**5.78**

ANA = Area Not Accessible

* Calculations are questionable due to small sample size

Table 99. Full FSE Dry Film Thickness Results by FSE Component

Nitrogen Servicing Cart, SN: NRR073

Location	06 Mar 2008 (mils)	03 Feb 2009 (mils)	04 Nov 2009 (mils)
1	14.20	9.53	12.30
2	9.66	8.32	7.76
3	7.56	5.55	7.76
4	4.99	4.11	5.24
5	3.99	4.07	NT
6	4.96	4.66	NT
7	3.17	3.35	5.33
8	4.11	2.85	4.46
9	5.14	5.22	5.60
10	2.48	3.70	5.49
11	7.93	7.26	6.89
12	10.40	7.91	8.73
13	10.50	11.00	9.72
14	14.20	18.20	16.90
15	13.60	13.00	14.80
16	8.29	9.84	9.13
17	8.27	11.10	11.40
18	6.94	8.50	10.20
19	7.95	6.46	8.40
20	6.82	4.34	6.42
Mean (μ)	**7.76**	**7.45**	**8.70**
Standard Deviation (σ)	**3.53**	**3.88**	**3.43**

NT = Not Taken

Nitrogen Servicing Cart, SN: NRR204

Location	06 Mar 2008 (mils)	03 Feb 2009 (mils)	04 Nov 2009 (mils)
1	6.56	6.84	6.39
2	5.47	5.81	5.59

Location	06 Mar 2008 (mils)	03 Feb 2009 (mils)	04 Nov 2009 (mils)
3	6.22	6.25	6.18
4	5.88	5.66	5.54
5	5.18	5.09	5.81
6	10.40	7.61	6.40
7	7.02	5.70	5.52
8	5.56	6.06	5.56
9	9.88	9.03	9.20
10	7.57	7.41	7.45
11	11.40	10.60	11.90
12	9.15	9.17	8.61
13	6.94	6.01	4.97
14	6.01	6.10	7.56
15	10.10	8.75	10.10
16	9.09	9.02	NT
17	7.72	6.01	5.85
18	9.59	7.85	7.55
19	5.64	7.30	7.14
20	6.96	8.08	8.19
Mean (μ)	**7.62**	**7.22**	**7.13**
Standard Deviation (σ)	**1.92**	**1.51**	**1.82**

NT = Not Taken

J52 Aft Engine Yoke, SN: P9H513

Location	30 Jan 2008 (mils)	17 Jul 2008 (mils)	27 Jan 2009 (mils)
1	2.77	5.60	3.90
2	1.67	2.30	5.70
3	2.77	3.60	3.20
4	3.10	3.50	2.80
5	3.83	3.90	3.30
6	3.70	4.00	2.50

Location	30 Jan 2008 (mils)	17 Jul 2008 (mils)	27 Jan 2009 (mils)
7	3.93	5.94	2.50
8	3.60	4.32	2.50
9	1.92	2.62	5.50
10	3.10	2.60	2.50
11	NT	NT	6.60
12	NT	NT	5.60
Mean (μ)	**3.04**	**3.84**	**3.88**
Standard Deviation (σ)	**0.78**	**1.22**	**1.53**

NT = Not Taken

C-130 Nose Landing Gear Forward Door, AC: 92-1534

Location	May 2008 (mils)	July 2009 (mils)
1	3.8	3.2
2	3.1	2.9
3	3.5	2.8
4	3.5	3.5
5	2.8	3.0
6	3.0	3.4
7	3.2	2.7
8	2.7	2.8
9	2.4	2.1
10	2.5	3.1
11	3.1	3.4
12	3.4	3.4
Mean (μ)	**3.08**	**3.03**
Standard Deviation (σ)	**0.43**	**0.40**

C-130 Nose Landing Gear Aft Door, AC: 92-1534

Location	May 2008 (mils)	July 2009 (mils)
1	2.8	3.0
2	2.1	2.5
3	2.0	2.2
4	2.1	ANA
5	1.9	ANA
6	1.8	ANA
7	2.2	2.5
8	1.9	2.2
9	1.8	1.9
Mean (μ)	**2.07**	**2.38**
Standard Deviation (σ)	**0.31**	**0.38**

ANA = Area Not Accessible

APPENDIX G: COST ASSESSMENT DATASHEETS

Table 100. Fleet Readiness Center – Northwest ECAM Data

Operate/Maintain Equipment and Facilities:

1. Cost of PPE				Notes
Employees				
Powder Coat Shop	5	painters		**Assumption: 5 painters work in PC shop**
Wet Paint Shop	5	painters		**Assumption: 5 painters work in wet paint shop**
PPE Items				For blasting operations to prepare components
Heavy Duty Blast Suit	$179.21	per unit		**Assumption: suit replaced twice a year**
PPE Items				For current powder coating operations
Kleengard coveralls	$4.28	per unit		25 coveralls to a box, 4 boxes per year (P/N 44334)
Particle filters	$4.82	per box		Each box contains one pair. Used 3 times (i.e. 3 days max with SOP of 8 hr max usage)
Kleengard gloves	$3.00	per box		100 gloves (50 pairs) per box. Usage time equals particulate filter limit
Full Face Respirator	$213.69	per unit		Replace once every 6 months (Ogden's example: 3M 7800 series)
Respirator cartridges	$18.17	per pair		Use one pair per day with Full face respirator (Odgen's example 3M 60926)
Annual man-days per painter	250	days		
Annual man-hours per painter	2,000	hours		
Estimated Annual Cost of PPE				Wet process requires full tyvek suit, full face respirator, and cartridges. The switch to PC requires only the use of particulate filters and gloves. Both processes require the blast suit.
Per Employee (wet paint)	$5,418.90			
Per Employee (LTCPC)	$765.09			
For All Paint Shop Operators (wet)	$27,094.50			
For All Paint Shop Operators (LTCPC)	$3,825.43			

2. Cost of Facility Safety Equipment				Notes
				Need additional information from Chris

3. O&M of Environmental Equipment & Facilities

				Notes
Personnel required Enlisted (E-3)	4	military members		
CII (BOSC Contractor)	2	contractors		**Assumption: 2 Base Operating Support Contractors (BOSC) from Chugach Industries, Inc (CII) are utilized for this activity**
Total man-hours required for these actions				
Enlisted (E-3)	60	hrs		**Assumption: 60 man-hours are required between the 4 military members**
CII (BOSC Contractor)	30	hrs		**Assumption: 30 man-hours are required between the 2 BOSC contractors**
Composite Rate (FY10) Annual Rate, Navy, E3	$54,661.00	per year		Based on information gathered from Office of the USD (Comptroller) website http://www.defenselink.mil/comptroller/rates/ and current as of September 2009.
Average Hourly Rate Enlisted (E-3)	$30.06	per hour		Estimate includes basic pay, retirement accruals, BAH, BAS, incentive and special pay, PCS expenses, and misc pay
CII (BOSC Contractor)	$100.00	per hour		These hourly rates estimate the average fully burdened cost (to include LMS and fringe benefits) to the government **Assumption: The BOSC contractor's fully burdened rate equals $100 per hour**
Estimated O&M Labor Costs Enlisted (E-3)	$1,803.81			
CII (BOSC Contractor)	$3,000.00			

4. Cost of Haz Mat Storage Drums and Materials

				No information given

Provide and Administer Training:

1. Thru 4. Training Course Requirements

				Notes
Contractor Provided Training Type	12	students (max)		One-day PC training fixed for a maximum of 12 students
Employee Resources Required for Training				
In-House Instructor	1	civilian		**Assumption: One civilian at GS-11 pay grade to wet painting school course**
Contractor Instructor	1	contractor		**Assumption: One contractor required to conduct conduct in-house PC training**
Training Course Length				
Wet painting school	15	days		Wet painting school is Navy-run
Powder coating training	1	day		In-house training is contractor provided
Number of Painters attending courses				
Wet Painting school	1	painter (min)		3 students attended in FY09; has been 1 or 2 in previous years
	3	painters (max)		
Powder coating training	1	painter (min)		
	3	painters (max)		
GS-11 Annual Base Salary	$49,544.00	min		Based on information gathered from DoD Civilian Personnel Management Service website http://www.cpms.osd.mil/wage/wage_schedules.aspx and current as of 3 September 2009
	$64,403.00	max		
Average Local Market Supplement (LMS)	18.06%			Added on top of base salary Locality Pay Area Definitions can be found at http://www.opm.gov/oca/09tables/locdef.asp **Based upon feedback provided by Warrren, a "composite" locality suppliment rate will be used based upon the average of Whidbey Island, North Island, Hill, and Warner-Robin's rates**
OMB total fringe benefits rate factor	36.25%			Based on information gathered from the Office of Management and Budget (OMB) Circular No. A-76 "Performance of Commercial Activities" text document http://edocket.access.gpo.gov/2008/E8-5549.htm and current as of March 19, 2008
Avg Annual Salary + LMS (BioEnv)				Assume straight average of full pay band plus LMS added on top. Assume a work period of 2080 hours per year (52 wk/yr * 40 hr/wk)
GS-11	$67,260.07			
Avg Hourly Rate				
GS-11	$44.06			These hourly rates estimate the average fully burdened cost (to include fringe benefits) to the government

1. Thru 4. Training Course Requirements

				Notes
Composite Rate (FY10)				Based on information gathered from Office of the USD (Comptroller) website http://www.defenselink.mil/comptroller/rates/ and current as of September 2009.
Annual Rate, Navy, E3	$54,661.00	per year		
Average Hourly Rate				
Painter (E-3)	$30.06	per hour		Estimate includes basic pay, retirement accruals, BAH, BAS, incentive and special pay, PCS expenses, and misc pay **Assumption: Average enlisted rank of Navy painters is E-3.**
In-House Instructor	$44.06	per hour		These hourly rates estimate the average fully burdened cost (to include fringe benefits) to the government
Contractor Instructor	$100.00	per hour		**Assumption: The contract instructor's fully burdened rate equals $100 per hour**
Estimated Annual Training Labor Costs				
Paint Shop Operators	$7,696.27			Loss of productive labor for these workers with LTCPC; one day less of training for wet paint
In-House Instructors	$5,287.03			
Contractor Instructor	$800.00			Only required for LTCPC process
Estimated Initial Training Labor Costs				For all 5 painters to initially receive training at switch over to LTCPC
Paint Shop Operators	$1,202.54			
Contractor Instructor	$800.00			

5. Annual Training Hours for Employees

				Notes
Employees				
Powder Coat Shop	5	painters		**Assumption: 5 painters work in PC shop**
Wet Paint Shop	5	painters		**Assumption: 5 painters work in wet paint shop**
Required training hours for painters	1	hr/year		1 hour refresher training annually after initial training **No change for switch from wet to PC processes**
Composite Rate (FY10)				Based on information gathered from Office of the USD (Comptroller) website http://www.defenselink.mil/comptroller/rates/ and current as of September 2009.
Annual Rate, Navy, E3	$54,661.00	per year		
Average Hourly Rate				
Painter (E-3)	$30.06	per hour		Estimate includes basic pay, retirement accruals, BAH, BAS, incentive and special pay, PCS expenses, and misc pay **Assumption: Average enlisted rank of Navy painters is E-3. The refresher course is self-paced and requires no instructor.**
Estimated Annual Training Labor Costs				
Paint Shop Operators	$150.32			loss of productive labor for these workers

6. Cost of Purchased Training Materials

	$0.00			No significant costs to report for the wet process or LTCPC

7. Cost of Developing In-House Training Materials

				Notes
Personnel required Course Developer	1	civilian		Training materials for SOP training **Assumption: One civilian at GS-9 pay grade to develop courseware**
Total man-hours required for these actions Course developer	40	hrs		**Assumption: Approximately 40 hours to develop the SOP training courseware**
GS-9 Annual Base Salary	$40,949.00 $53,234.00	min max		Based on information gathered from DoD Civilian Personnel Management Service website http://www.cpms.osd.mil/wage/wage_schedules.aspx and current as of 3 September 2009
Average Local Market Supplement (LMS)	18.06%			Added on top of base salary Locality Pay Area Definitions can be found at http://www.opm.gov/oca/09tables/locdef.asp **Based upon feedback provided by Warrren, a "composite" locality suppliment rate will be used based upon the average of Whidbey Island, North Island, Hill, and Warner-Robin's rates**
OMB total fringe benefits rate factor	36.25%			Based on information gathered from the Office of Management and Budget (OMB) Circular No. A-76 "Performance of Commercial Activities" text document http://edocket.access.gpo.gov/2008/E8-5549.htm and current as of March 19, 2008
Avg Annual Salary + LMS (BioEnv) GS-9	$55,593.87			Assume straight average of full pay band plus LMS added on top. Assume a work period of 2080 hours per year (52 wk/yr * 40 hr/wk)
Avg Hourly Rate GS-9	$36.42			These hourly rates estimate the average fully burdened cost (to include fringe benefits) to the government
Estimated Internal Audit Labor Costs New LTCPC Checklist	$1,456.67			**No change for switch from wet to PC processes**

Obtain and Maintain Permits:

1. Permits for Process

				Notes
Permits Required Blast booth permit Wet Paint booth permit	 $1,100.00 $1,100.00			Only an initial fee was paid; there are no renewal fees. **Wet paint booth permits will not be required with switch to LTCPC**
Estimated Annual Permitting Costs Annual Cost of Title V Permit	 $500.00			There is an estimated annual cost to 900 Division for Title V permitting that will exist regardless of the paint process being wet or powder coat.

Support Facility Operations:

2. Internal Audit Teams

				Notes
Personnel required Civilian	 5	 civilians		From the N44 department; typical paygrade is GS-9 or GS-11 **No change for switch from wet to PC process**
Total man-hours required for these actions Civilian	 8	 hrs		2 man-hours total per quarter; 4 audits per year; same 2 waste streams (blasting for heavy metals and paint gun washer solvent) audited each time 2 man-hours per quarter
GS-9 Annual Base Salary	$40,949.00 $53,234.00	min max		Based on information gathered from DoD Civilian Personnel Management Service website http://www.cpms.osd.mil/wage/wage_schedules.aspx and current as of 3 September 2009
GS-11 Annual Base Salary	$49,544.00 $64,403.00	min max		
Average Local Market Supplement (LMS)	18.06%			Added on top of base salary Locality Pay Area Definitions can be found at http://www.opm.gov/oca/09tables/locdef.asp **Based upon feedback provided by Warrren, a "composite" locality suppliment rate will be used based upon the average of Whidbey Island, North Island, Hill, and Warner-Robin's rates**
OMB total fringe benefits rate factor	36.25%			Based on information gathered from the Office of Management and Budget (OMB) Circular No. A-76 "Performance of Commercial Activities" text document http://edocket.access.gpo.gov/2008/E8-5549.htm and current as of March 19, 2008

2. Internal Audit Teams

				Notes
Avg Annual Salary + LMS (BioEnv)				Assume straight average of full pay band plus LMS added on top. Assume a work period of 2080 hours per year (52 wk/yr * 40 hr/wk)
GS-9	$55,593.87			
GS-11	$67,260.07			
Avg Hourly Rate				These hourly rates estimate the average fully burdened cost (to include fringe benefits) to the government
GS-9	$36.42			
GS-11	$44.06			
Estimated Internal Audit Labor Costs				
GS-9	$174.80			**Assumption: 2 GS-11 employees and 3 GS-9 employees**
GS-11	$140.99			

3. Internal Audit Checklists and Documentation

				Notes
Personnel required				
Civilian	1	civilian		From the N44 department; typical paygrade is GS-9 or GS-11 **Assumption: One civilian at GS-9 or GS-11 pay grade to develop audit checklists and documentation**
Total man-hours required for these actions				
Civilian	2	hrs		2 man-hours for the single new anticipated LTCPC checklist
GS-9 Annual Base Salary	$40,949.00	min		Based on information gathered from DoD Civilian Personnel Management Service website http://www.cpms.osd.mil/wage/wage_schedules.aspx and current as of 3 September 2009
	$53,234.00	max		
GS-11 Annual Base Salary	$49,544.00	min		
	$64,403.00	max		
Average Local Market Supplement (LMS)	18.06%			Added on top of base salary Locality Pay Area Definitions can be found at http://www.opm.gov/oca/09tables/locdef.asp **Based upon feedback provided by Warrren, a "composite" locality suppliment rate will be used based upon the average of Whidbey Island, North Island, Hill, and Warner-Robin's rates**
OMB total fringe benefits rate factor	36.25%			Based on information gathered from the Office of Management and Budget (OMB) Circular No. A-76 "Performance of Commercial Activities" text document http://edocket.access.gpo.gov/2008/E8-5549.htm and current as of March 19, 2008
Avg Annual Salary + LMS (BioEnv)				Assume straight average of full pay band plus LMS added on top. Assume a work period of 2080 hours per year (52 wk/yr * 40 hr/wk)
GS-9	$55,593.87			

3. Internal Audit Checklists and Documentation — **Notes**

				Notes
GS-11	$67,260.07			
Avg Hourly Rate				These hourly rates estimate the average fully burdened cost (to include fringe benefits) to the government
GS-9	$36.42			
GS-11	$44.06			
Estimated Internal Audit Labor Costs				One initial cost of development in support of LTCPC conversion
New LTCPC Checklist	$80.48			**Assumption: Having a single civilian requirement, the rates for GS-9 and GS-11 will be averaged to utilize a midrange value.**

4. Internal Audit Reports — **Notes**

				Notes
Personnel required				
Civilian	1	civilian		From the N44 department; typical paygrade is GS-9 or GS-11 **Assumption: One civilian at GS-9 or GS-11 pay grade to develop audit checklists and documentation**
Total man-hours required for these actions				
Civilian	16	hrs		4 man-hours per quarterly inspection; 4 inspections per year
GS-9 Annual Base Salary	$40,949.00	min		Based on information gathered from DoD Civilian Personnel Management Service website http://www.cpms.osd.mil/wage/wage_schedules.aspx and current as of 3 September 2009
	$53,234.00	max		
GS-11 Annual Base Salary	$49,544.00	min		
	$64,403.00	max		
Average Local Market Supplement (LMS)	18.06%			Added on top of base salary Locality Pay Area Definitions can be found at http://www.opm.gov/oca/09tables/locdef.asp **Based upon feedback provided by Warrren, a "composite" locality suppliment rate will be used based upon the average of Whidbey Island, North Island, Hill, and Warner-Robin's rates**
OMB total fringe benefits rate factor	36.25%			Based on information gathered from the Office of Management and Budget (OMB) Circular No. A-76 "Performance of Commercial Activities" text document http://edocket.access.gpo.gov/2008/E8-5549.htm and current as of March 19, 2008
Avg Annual Salary + LMS (BioEnv)				Assume straight average of full pay band plus LMS added on top. Assume a work period of 2080 hours per year (52 wk/yr * 40 hr/wk)
GS-9	$55,593.87			
GS-11	$67,260.07			
Avg Hourly Rate				These hourly rates estimate the average fully burdened cost (to include fringe benefits) to the government

4. Internal Audit Reports — **Notes**

GS-9	$36.42			
GS-11	$44.06			
Estimated Internal Audit Labor Costs New LTCPC Checklist	$643.80			**Assumption: Having a single civilian requirement, the rates for GS-9 and GS-11 will be averaged to utilize a midrange value.**

5. Component Waste Production

				No information given

6. On-Site Waste Treatment

On-site treatment doesn't occur at FRC-NW	$0.00			

7. On-Site Waste Disposal

On-site disposal doesn't occur at FRC-NW	$0.00			

8. & 9. Off-Site Waste Treatment and Disposal — **Notes**

Contract Type				Contractors are utilized for off-site treatment (Phillips Environmental Services) Utilizes BOSC contractors managed by DRMO; Cost of transportation included in the cost of the DRMO contract.
Contracted Waste Rate				
Annual waste amount (Wet paint)	1,760	lbs per year		
Annual waste amount (LTCPC)	500	lbs per year		
Contractor Rates	$ 0.37	per lb		
Estimated Offsite Treatment Cost				
Waste T&D (Wet paint)	$ 651.20			Contractor labor plus materials
Waste T&D (LTCPC)	$ 185.00			

10. Unused Hazardous Material Disposal — **Notes**

Wet Process unused materials				
Flammable waste	minimal			Volume varies but is typically minimum; recycled on base whenever possible
Toxic waste	minimal			
PC unused materials				
None	$0.00			

11. On-site HazMat Handling, Transporation, and Storage — **Notes**

Personnel required				
Civilian	2	civilians		From the N44 department; typical paygrade is GS-7
Enlisted (E-3)	3	military members		**This labor only applies to the wet painting operation**
Total man-hours required for these actions Civilian + Military	96	hrs		8 hours per month amongst the 5 workers
GS-7 Annual Base Salary	$33,477.00	min		Based on information gathered from DoD Civilian Personnel Management Service website http://www.cpms.osd.mil/wage/wage_schedules.aspx and current as of 3 September 2009
	$43,521.00	max		
Composite Rate (FY10) Annual Rate, Navy, E3	$54,661.00	per year		Based on information gathered from Office of the USD (Comptroller) website http://www.defenselink.mil/comptroller/rates/ and current as of September 2009.
Average Local Market Supplement (LMS)	18.06%			Added on top of base salary Locality Pay Area Definitions can be found at http://www.opm.gov/oca/09tables/locdef.asp **Based upon feedback provided by Warrren, a "composite" locality suppliment rate will be used based upon the average of Whidbey Island, North Island, Hill, and Warner-Robin's rates**
OMB total fringe benefits rate factor	36.25%			Based on information gathered from the Office of Management and Budget (OMB) Circular No. A-76 "Performance of Commercial Activities" text document http://edocket.access.gpo.gov/2008/E8-5549.htm and current as of March 19, 2008
Avg Annual Salary + LMS GS-7	$45,449.99			Assume straight average of full pay band plus LMS added on top. Assume a work period of 2080 hours per year (52 wk/yr * 40 hr/wk)
Avg Hourly Rate GS-7	$29.77	per hour		These hourly rates estimate the average fully burdened cost (to include fringe benefits) to the government

11. On-site HazMat Handling, Transporation, and Storage

				Notes
Enlisted (E-3)	$30.06	per hour		Estimate includes basic pay, retirement accruals, BAH, BAS, incentive and special pay, PCS expenses, and misc pay
Estimated HazMat Handling, Transport, and Storage Labor Costs Civilian + Military	$2,874.90			**Assumption: Each of the 5 individuals will share the hours equally amongst themselves**

12. Off-site Waste Treatment and Disposal

	$0.00			BOSC contractor manages this. Look to questions 9 & 10 above

<u>Develop and Maintain Documentation:</u>

1. Following Activities

				Notes
Personnel required Civilian	10	civilians		Typical paygrade is GS-9, GS-11, and GS-12 **Assumptions: Team of 10 consists of: 5 GS-9 civilians; 3 GS-11 civilians; and 2 GS-12 civilians Time is shared equally between all employees; i.e. GS-9s = 50%, GS-11s = 30%, and GS-12s = 20%**
Total man-hours required for these actions Civilian (Wet Paint)	292	hrs		**Assumption: Time required for each task • Create and maintain MSDS forms - 8 hrs • Prepare spill/release emergency plans - 12 hrs • Prepare accident plans - 12 hrs • Perform internal industrial hygiene survey/report - 40 hrs • Oversee industrial hygiene audit by external agency - 24 hrs • Develop employee duties/responsibilities/procedures - 12 hrs • Prepare TRI reports - 40 hrs • Prepare EPCRA reports - 40 hrs • Prepare state reports - 40 hrs • Develop and maintain programs and procedures - 12 hrs • Develop and maintain strategic plans and budgets - 24 hrs • Prepare container labels - 8 hrs • Fill manifest forms - 8 hrs • Prepare supply orders - 12 hrs**
Civilian (LTCPC)	252	hrs		

1. Following Activities | **Notes**

GS-9 Annual Base Salary	$40,949.00	min		Based on information gathered from DoD Civilian Personnel Management Service website http://www.cpms.osd.mil/wage/wage_schedules.aspx and current as of 3 September 2009
	$53,234.00	max		
GS-11 Annual Base Salary	$49,544.00	min		
	$64,403.00	max		
GS-12 Annual Base Salary	$59,383.00	min		
	$77,194.00	max		
Average Local Market Supplement (LMS)	18.06%			Added on top of base salary Locality Pay Area Definitions can be found at http://www.opm.gov/oca/09tables/locdef.asp **Based upon feedback provided by Warrren, a "composite" locality suppliment rate will be used based upon the average of Whidbey Island, North Island, Hill, and Warner-Robin's rates**
OMB total fringe benefits rate factor	36.25%			Based on information gathered from the Office of Management and Budget (OMB) Circular No. A-76 "Performance of Commercial Activities" text document http://edocket.access.gpo.gov/2008/E8-5549.htm and current as of March 19, 2008
Avg Annual Salary + LMS (BioEnv)				Assume straight average of full pay band plus LMS added on top. Assume a work period of 2080 hours per year (52 wk/yr * 40 hr/wk)
GS-9	$55,593.87			
GS-11	$67,260.07			
GS-12	$80,617.99			
Avg Hourly Rate				These hourly rates estimate the average fully burdened cost (to include fringe benefits) to the government
GS-9	$36.42			
GS-11	$44.06			
GS-12	$52.81			
Estimated Various Activities Labor Costs				**The only change for switch from wet to PC process would be the exclusion of TRI reporting for LTCPC**
Develop & Maintain Documents (Wet)	$12,260.39			
Develop & Maintain Documents (LTCPC)	$10,580.88			

Legend

Collected Data	Calculated ECAM Costs
Assumption-Based Values	Information Gaps

Table 101. Ogden Air Logistics Center ECAM Data

Bioenvironmental Actions:

1. Bioenvironmental Engineering Surveys				Notes
Personnel required for survey	1	person		YH-02 grade person to complete survey; limited supervisory role for YJ-02 person
Man-hours required for survey				Time for YH-02 executor depends on shop issues and the review process, time would include RPP training
NSPS YH-02	4	hr (min)		
	10	hr (max)		
NSPS YJ-02	2	hr		Time for YJ-02 review of shop information
Consumables				Only if air sampling is accomplished as part of survey. Media costs and lab analysis costs are not tracked to specific shops
NIOSH 7300 Analysis				
SKC catalog 225-5				
NIOSH 7604/7600 Analysis				
225-803				
Total/Respirable Dust Analysis				
225-532				
Solvent Analysis				
226-01 tubes				
Other				The elimination of liquid primer would not significantly impact man-hours connected with shop assessments. The workers would still use respirators for training and therefore still need RP training and occupational physicals. Only cost elimination would be for the liquid primer sampling that is conducted by BioEnv
NSPS YH-02 Annual Base Salary	$40,093.00	min		Based on information gathered from DoD Civilian Personnel Management Service website http://www.cpms.osd.mil/wage/wage_sched_suppl.aspx and current as of 4 January 2009
	$108,483.00	max		
NSPS YJ-02 Annual Base Salary	$58,141.00	min		
	$113,908.00	max		
Average Local Market Supplement (LMS)	18.06%			Added on top of base salary (value averaged for Hill, Warner-Robins, North Island, and Whidbey Island)

1. Bioenvironmental Engineering Surveys — Notes

				Notes
OMB total fringe benefits rate factor	36.25%			Based on information gathered from the Office of Management and Budget (OMB) Circular No. A-76 "Performance of Commercial Activities" text document http://edocket.access.gpo.gov/2008/E8-5549.htm and current as of March 19, 2008
Avg Annual Salary + LMS (BioEnv)				Assume straight average of full pay band plus LMS added on top. Assume a work period of 2080 hours per year (52 wk/yr * 40 hr/wk)
NSPS YH-02	$87,700.70			
NSPS YJ-02	$101,556.22			
Avg Hourly Rate				These hourly rates estimate the average fully burdened cost (to include fringe benefits) to the government
NSPS YH-02	$57.45			
NSPS YJ-02	$66.52			
Estimated Survey Labor Costs				
NSPS YH-02	$402.14			
NSPS YJ-02	$133.05			

2. Annual Physicals and Fit-Testing — Notes

				Notes
Personnel required for physical/fit testing	4	people (min)		At Hill AFB, Occupational Medicine performs the physicals and respirator fit-testing. Occupational Medicine at Hill is provided by contractor service.
	5	people (max)		
Total man-hours required for these actions	2	hr (min)		Time is for all Occ Med workers combined
	4	hr (max)		
Consumables				Specific cost of consumables for this process is not known by Bioenvironmental Engineering
Workers in Powder Paint Shop	5	people		Due to HIPAA laws each worker is subjected to physicals and respirator fit-tests separately. Time required of individual equals the total for Occ Med personnel listed above. (Means the Occ Med people time will have to be multipled by the number of employees)
Other				Total cost has not been previously estimated for this shop since it is unknown to BioEnv if the contract (Occ Med) was bid on a cost-per-person basis or on a total number of annual occupational physicals basis.
				The elimination of liquid primer would not significantly change these costs since these workers would still wear respirators (No Change)
WG-09 Hourly Rates				Based on information gathered from DoD Civilian Personnel Management Service website http://www.cpms.osd.mil/wage/wage_schedules.aspx for the Utah area (139) and current as of September 2008.

2. Annual Physicals and Fit-Testing				**Notes**
Step 1	$20.52			
Step 2	$21.37			
Step 3	$22.23			
Step 4	$23.07			
Step 5	$23.92			
Average Hourly Rate				
Occ Med Personnel	$100.00			**Assumption: Occupational Medicine fully burdened rate of $100 per hour.**
Paint Shop Operators	$35.74			These hourly rates estimate the average fully burdened cost (to include LMS and fringe benefits) to the government
Estimated Physical/Fit-test Labor Costs				
Occ Med Personnel	$300.00			**Assumption: Annual physicals and fit-testing will be the same for Hill AFB and FRC-NW**
Paint Shop Operators	$536.16			loss of productive labor for these workers

3. Annual Respirator Training				**Notes**
Personnel required for training	1			YH-02 grade person to complete training; no consumables used for training and no other costs involved.
Man-hours required for training (range)	0.5	hr (min)		
	0.67	hr (max)		
Workers in Powder Paint Shop	5	people		The powder paint shop personnel are trained as a group and not individually
Other				The elimination of liquid primer would not significantly change these costs since these workers would still wear respirators (No Change)
Estimated Respirator Training Labor Costs				
NSPS YH-02	$33.51			
Paint Shop Operators	$104.25			loss of productive labor for these workers

4. Cost of PPE | **Notes**

PPE items				The Bioenvironmental Engineering Shop does not have access to information regarding the cost of PPE for the Powder Paint Shop. The respirators, cartridges, gloves, eye protection, aprons, coveralls, etc are ordered by Air Force supply personnel in bulk and provided as needed to workers. Costs would be dependent on the source of supply. It is unknown who would have these specific costs.
Tyvek coveralls 1 pr/day example DuPont TY120S	$3.95	/pair		Based on representative product costs gathered from GSA Advantage website https://www.gsaadvantage.gov/advgsa/advantage/catalog/product_detail.do?contractNumber=GS-06F-0006T&BV_UseBVCookie=Yes&itemNumber=TY120S+M on August 24, 2009
Or Lab Coat 1/wk example DuPont TY212S	$2.77	/unit		https://www.gsaadvantage.gov/advgsa/advantage/catalog/product_detail.do?contractNumber=GS-06F-0013N&BV_UseBVCookie=Yes&itemNumber=TY212SWH2X00+%28161371%29
Nitrile gloves 1-2 pr/day or more example Best 8005 disposable nitrile gloves	$13.91	/box (25 pairs/box)		https://www.gsaadvantage.gov/advgsa/advantage/catalog/product_detail.do?contractNumber=GS-06F-0074R&BV_UseBVCookie=Yes&itemNumber=8005L
Safety Glasses 1 pr/mo example NORTH SAFETY T56555B	$5.41	/pair		https://www.gsaadvantage.gov/advgsa/advantage/catalog/product_detail.do?contractNumber=GS-06F-0032K&BV_UseBVCookie=Yes&itemNumber=H09775
Supplied Air Hood 1/day example 3M Hood System BE series	$25.36	/unit		https://www.gsaadvantage.gov/advgsa/advantage/catalog/product_detail.do?contractNumber=GS-21F-0029V&BV_UseBVCookie=Yes&itemNumber=051138-72088
Full Face Respirator 1/6 mo example 3M 7800 series	$213.69	/unit		(Note: the worker can choose either the supplied air hood or the full-face cartridge respirator. If the full-face cartridge one is used, the cartridges must be replaced daily. When a supplied air hood is purchased, the breathing tube, hose and hood are separate items. The breathing tube would be reusable, the hood part disposable and the air lines supplying the hood reusable.)
Respirator cartridges 1 pr/day example 3M 60926	$18.17	/pair		believe these supply people are DLA employees. You could try their customer support office, DLA/CS 801-777-0336
Estimated Annual Cost of PPE				
Per Employee	$6,312.09			
For All Paint Shop Operators	$31,560.46			

Legend

Collected Data	Calculated ECAM Costs
Assumption-Based Values	Information Gaps