Boeing Technology

Nonchromate Conversion Coatings in use at Boeing

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Overview

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- **Objective: Summary of two processes used at Boeing that reduce or eliminate the use of chromates**
- **Boric Sulfuric Acid Anodizing (BSAA)**
  - **replaces chromic acid anodizing**
- **Boegel conversion coatings**
  - **Conversion coating based on sol-gel chemistry**

MIL-A-8625F (10 Sept 1993)

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- **Types of Anodize Coatings**
  - **Type I – Chromic Acid Anodizing (40V)**
  - **Type IB – Chromic Acid Anodizing (22V)**
  - **Type IC – Non-chromic acid anodizing, for use as a non-chromate alternative for Type I and IB coatings (BSAA=15V)**
  - **Type IIB – Thin sulfuric acid anodizing, for use as a non-chromate alternative for Type I and IB coatings**
- **Specifics**
  - **(3.4.1) Type IC coating shall be the result of treating aluminum … in a bath containing mineral or mixed mineral/organic acids (non-chromic acid) …**
  - **(3.4.1.1) Type IC coatings provide a non-chromate alternative to Type I and IB coatings. Unless approved by the procuring activity, substitution of a Type IC coating where Type I or IB is specified shall be prohibited**
  - **Similar wording for Type IIB coatings in 3.4.2 and 3.4.2.1**

Type IC and IIB Caveats

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- **Suggested substitutions (6.1.2)**
  - **Type IC and IIB coatings provide non-chromate alternatives to Type I and IB coatings where corrosion resistance, paint adhesion, and fatigue resistance is required. Please note that Type IC or IIB may not serve as suitable replacements when the effects of electrolyte entrapment is the primary concern. Maximum Type IC and Type IIB coating weights of 700 mg/ft2 and 1000 mg/ft2, respectively, are specified in Table I for fatigue purposes. …**
- **Effect on fatigue (6.10.7)**
  - **The fatigue properties of aluminum alloys can be severely reduced by anodic coatings. The amount of reduction varies with the process. As a general rule, the thicker the coating the greater the reduction in fatigue will be.**

Boric Sulfuric Acid Anodizing

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- **Direct replacement of chromic acid anodizing**
  - **MIL-A-8625 Type I, Type IB, Type IC**
  - **Used on parts that are fatigue sensitive**
  - **Parts are almost invariably fully painted**
  - **Coating weights depend on alloy**
    - **2XXX are typically 200 to 500 mg/sq.ft.**
    - **7XXX are typically 400 to 700 mg/sq.ft.**
  - **Coating weight has tendency to self-limit**
  - **Fatigue debit is less than for CAA at similar coating weight**
  - **Seal required in BAC5632 is dilute chromate (<75ppm Cr(VI))**
    - **DI seal does work but not robust**
  - **"Class 5" unsealed is allowed for fully painted parts**
    - **Superior adhesion**

Test Data

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- **Boeing (Commercial Airplanes)**
  - **Extensive testing of BSAA for corrosion protection, paint adhesion, fatigue**
    - **Multiple sources**
  - **Approved for use on all models as a direct replacement for chromic acid anodizing**
- **Recent C-17 Results**
  - **Extensive testing of corrosion, adhesion, fatigue**
    - **Includes alloys, materials, requirements specific to C-17**
    - **Results consistent with Boeing and NAVAIR data**
- **NAVAIR**
  - **Test data to support MIL-A-8625 revisions, NAS-NI, others**
- **Air Force**
  - **Sacramento ALC, others?**

BSAA Usage

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- BSAA approved for use in place of CAA for all models of Commercial Airplanes
  - Class 5 unsealed allowed for fully painted parts
  - Class 5 is used for all wing components
    - Chromate primers (fuel tank, interior and exterior epoxy primers)
- Boeing Fabrication uses BSAA exclusively
  - Boeing Canada still has CAA
- 48 approved suppliers world wide (31 in USA)
  - Navy, Air Force installations
- No known performance issues with 15+ years experience in the commercial fleet

Implementation -- Drawing Finishing Call Out

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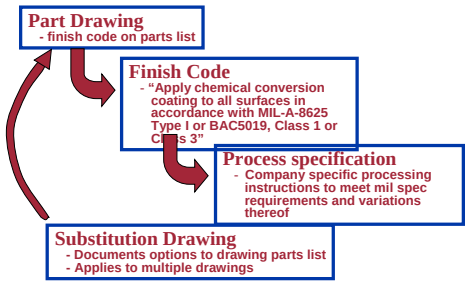
- FAA requires that all information required to build a part be on or referenced from the part drawing



Substitution Drawing for Implementation

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CAA to BSAA Transition Issues

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- Tanks and equipment
  - BSAA can corrode tanks/pumps/etc
    - Mild steel is not acceptable
- Assemblies
  - BSAA electrolyte is corrosive
    - Not appropriate for assemblies where solution may be trapped
    - Masking of dissimilar metals needs careful consideration

Boegel IIEP conversion coating

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- Boegel is Boeing developmental name
  - "Sol-Gel" describes a wide variety of processes
    - Not all "sol-gel" coatings are the same!
    - "Boegel" is a specific formulation based on sol-gel processing techniques
  - Licensed to AC Tech, Henkel, Socomor
- Mixed Zr/Si oxide system
  - Aqueous solution -- ~3-30% solids
- Silane component matched to primer, sealant, or adhesive
  - Boegel-EPII is epoxy functionalized – epoxy primers/adhesives
  - Boegel-AM is amino functionalized – polyimide adhesives
  - Boegel-HS is concentrated, high temp version
- Designed for spray/flood applications
  - Facilitate "just in time" fabrication
  - Easily scaleable to part size
    - Little/no overhead in facilities/tanks/process soluti
- Little or no waste
  - Neutralize and sewer
- Superior adhesion
  - Aluminum, titanium, CRES, nickel, …

Sol-Gel Chemistry Basics

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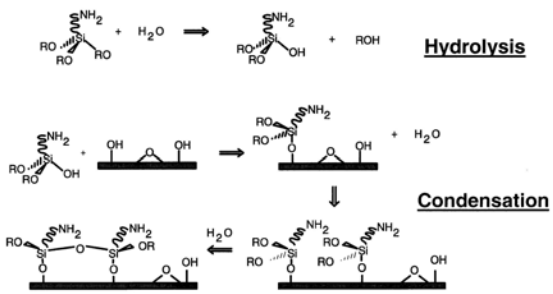

Designed Nanostructured Boegel Interface

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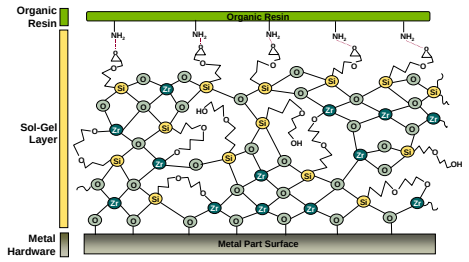

- Tailorable to different resin/paint chemistries
- Robust process conditions
- Greater range of properties using inorganic and hybrid polymers than current state-of-the art systems

Boegel Film Characteristics

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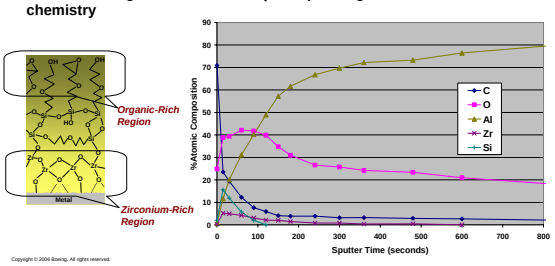
- Oriented film - Zr toward metal, organic on top
- ESCA/Auger shows aspects of gradient coating
- IR shows Si-O and organics
- XAS indicated M-O-Zr bond
- Thickness ranges from 20 nm – 1 μm depending on formulation chemistry



Colored Boegel EPII

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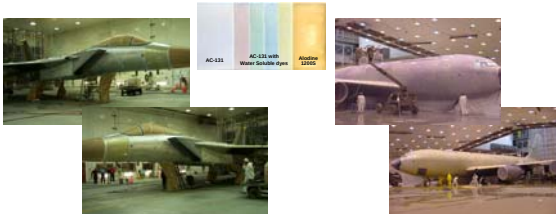
- Boegel/AC-131BB gives adequate coloration for process and end item evaluation
- No impact on performance properties



Key Results - Rain Erosion with rivets

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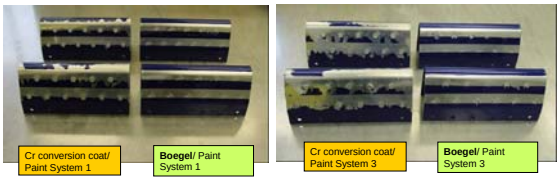

Rain erosion testing shows improved adhesion to rivets for two different paint systems when Boegel EPII is used as pretreatment.

Paint Adhesion to Titanium

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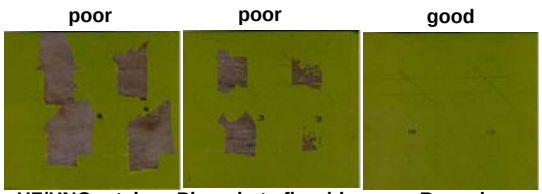
- Phosphate-fluoride is typical conversion coating for titanium
- Process tanks not available for large part so different approach was needed.
- Implemented as a change in process specification
  - Production Process since 1997



Specification Summary

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Ti/Ni/Stainless Painting	D950-10313-1, Rev C	Sol-Gel Conversion Coatings for Titanium Alloys
	BSMS-25-002	Sol-Gel Conversion Coating
	BSPS-07-002	Application of Sol-Gel Coating for Titanium Painting
	BAC 5665	Application of Sol-Gel Conversion Coatings on Corrosion Resistant Alloys for Painting
	XBMS 10-128	Sol-Gel Conversion Coating

Ti/Ni/Stainless Bonding	BSMS-25-001	Sol-Gel Coating for Metal Bonding
	BSPS-07-001,	Application of Sol-Gel Coating for Titanium Bonding
	D950-10413-1 Rev A	Sol-Gel Surface Treatment for Bonding Titanium Alloys
	XBAC5667	Sol-Gel Surface Treatment for Bonding of Corrosion Resistant Alloys
	XBMS5-162	Sol-Gel Coating for Metal Bonding

Al Paint	9-679N-KYB02-019	Sol-Gel Conversion Coatings for Aluminum Alloys
	BAC5663	Sol-Gel Conversion Coatings for Aluminum Alloys
	D6-1816	Paint Hangar Document

Al Bond	9-679N-KYB02-011	Sol-Gel Prebond Treatment for Aluminum Alloys
	SRM Chapter 51	Structural Repair Manuals, BCA

Implementation

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Everett Decorative Paint Operations implemented Boegel EPII/AC131-CB for 777s in March 2007

Elimination of ~ 400 gallons of chromated pretreatment and wastewater material per 777

Summarize applications

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- Painting Titanium parts
  - Several applications on B787
  - Tail cone
  - F-22 Booms and tubes
- Bonding
  - Ti rotor blade debris caps
  - Structural Repair of Aluminum aircraft
  - Several Ti-to-composite parts on B787
- Painting Aluminum
  - Wide body paint hangers (B777)
  - Part-by-part approval for components
    - Drawing changes, working on substitution dwg callout
- List is growing

Summary

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- Sol-gel technology can be used to improve performance while saving on manufacturing and environmental costs
- Inorganic polymer technology has just begun to be exploited as a means of forming polymer and composite systems
- These are enabling technologies in aerospace manufacture that will allow us to achieve new properties, enable new processes, and greater durability materials
- All sol-gels are not alike

Questions?

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