

Ogden Air Logistics Center



U.S. AIR FORCE

Corrosion Resistant Steels for Structural Aircraft Applications

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Introduction

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The Four Horsemen of Landing Gear Apocalypse



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Introduction

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- **300M/4340M low alloy steel most common landing gear material(280-300 ksi)**
 - **Relies on Cadmium plate for corrosion protection**
 - **300M extremely sensitive to**
 - Stress Corrosion Cracking (SCC)
 - Hydrogen Embrittlement
 - Corrosion
 - Thermal Damage
 - Low tempering temperature (575°F)
 - Grinding burns
 - In-service friction burns(over-temper)
 - **A corrosion resistant high strength stainless steel would**
 - Substantially reduce the above material sensitivities
 - Eliminate cadmium plating necessity



Introduction

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- **ESTCP project PP-0304 “Demonstration and Validation of Corrosion Resistant Steels for Structural Applications in Aircraft using an Accelerated Insertion Methodology”**
 - **Main focus to develop high strength stainless steel landing gear material**
 - Equal mechanical properties to 300M low alloy steel (Baseline)
 - Much improved corrosion and stress corrosion cracking resistance
 - Eliminate cadmium plating necessity
 - **SERDP program started in 2001**
 - **Alloy designated as Ferrium S53**
 - **Alloy developed by QuesTek Innovations**
 - **ESTCP program started FY 03**
- **Core Team members**
 - **QuesTek, Air Force, Rowan Technology, General Atomics**
- **Support team**
 - **Boeing, Lockheed, Navair, Northrup Grumman and Landing gear companies**



Summary of Technical Achievements



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- Major milestone first 10K ingot scale-up produced in Dec 04 at Carpenter(2 additional 10K ingots in process)
 - This size typical for a “production run” of specialty steels
 - Addressed scale-up and metallurgy and property issues
 - Initial chemistry analysis, tensile strength and charpy tests from 10K product forms met requirements
- Material properties on target(compared with 300M)
 - Ultimate tensile strength(280-300ksi)
 - Elastic modulus
- Material properties improved (compared to 300M)
 - % Elongation
 - RA(Reduction in Area)
 - K_{Ic} (Fracture Toughness)
 - K_{ISCC} (Stress Corrosion Cracking Threshold)
 - Charpy Impact Energy
- Material properties not on target
 - YS(.2% offset Yield Strength)
 - 216-225 ksi vs 230 ksi



Tests On-Going on Forged and Rolled Bars



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- **Product forms produced**
 - 8 “ diameter forged bar
 - 4”X 4” rolled bar
- **Investigations underway on bars and selected landing gear components**
 - Machining studies
 - Forging studies
 - Fabrication of landing gear component test articles
 - Property tests
 - Corrosion, Fatigue, Static, K_{ISCC} , K_{IC}
- **Goal at end of program to have qualified landing gear component ready for flight service evaluation**



Summary of Technical Achievements: 300 lb Heats



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■ Machining/grinding studies

- Machining studies in annealed condition underway
- Machining/grinding in harden condition similar to Aermet 100
- Shot-Peen investigation using X-ray diffraction
 - Same parameters as 300M
 - Depth and magnitude of residual stress profile similar to 300M

■ Initial fatigue testing (hour-glass, bare un-notched L-direction specimens, $R = -0.33$)

- Similar life to 300M at 190 ksi and 150 ksi stress level

■ Coatings Investigation

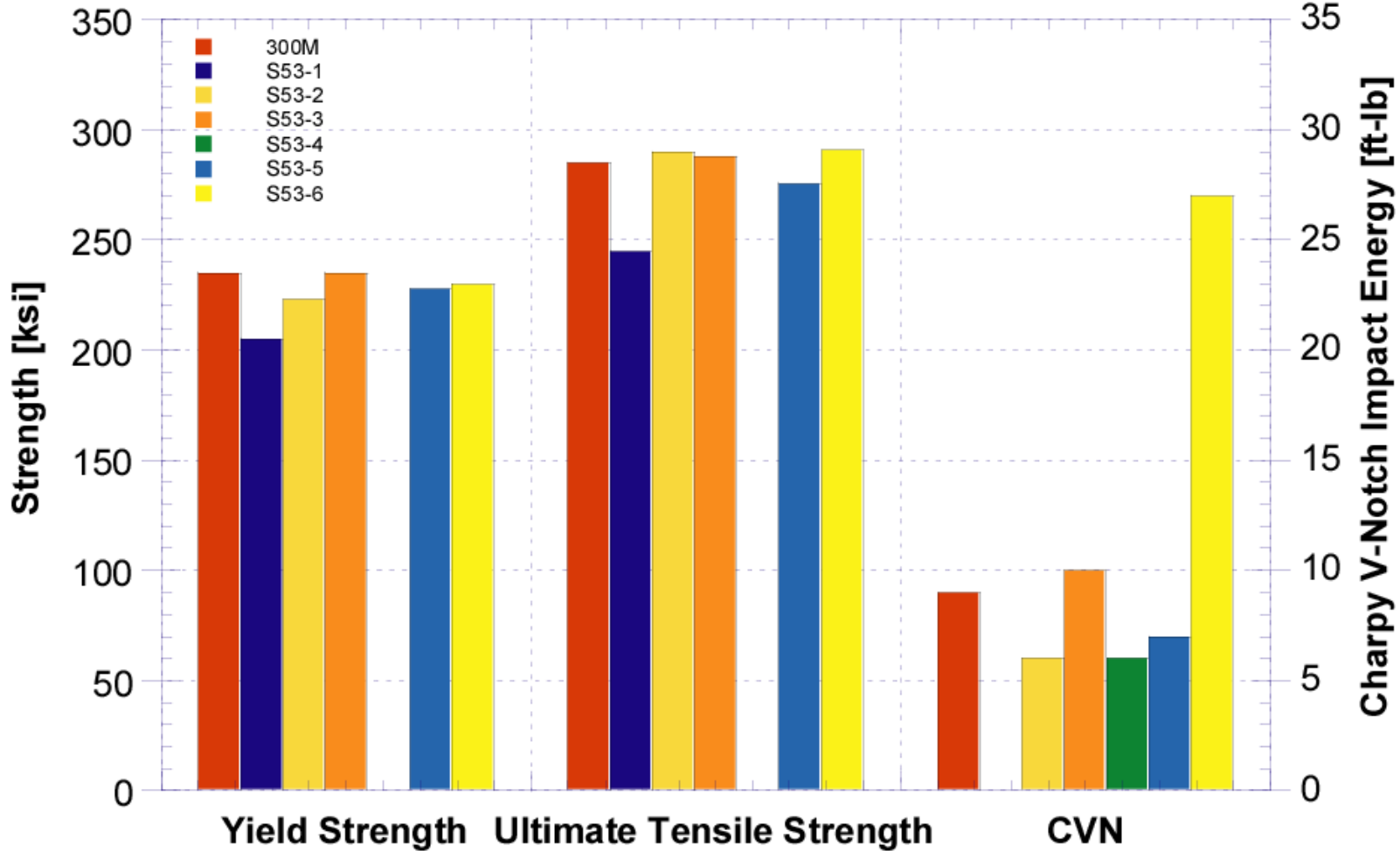
- Coatings used in Landing Gear: Electroplated chrome, nickel and HVOF sprayed WC-17Co, investigated for adherence
 - Gage zone of peened fatigue specimens coated and tested
 - Coatings adhere to S53 until specimen failure by fatigue
 - Fatigue debit from coatings on S53 similar to debit on 300M



Static Properties and CVN 300 lb Heat Data



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Fracture Toughness Improvements



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Alloy	K_{Ic} LRA-RSL	K_{Isc} LRA-RSL
S53-6F (L-T)	88 ksi-in ^{1/2}	50-60 ksi-in ^{1/2}
300M	50 ksi-in ^{1/2}	<10 ksi-in ^{1/2}



Corrosion Testing

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- Panels placed near ocean at Kure Beach, NC

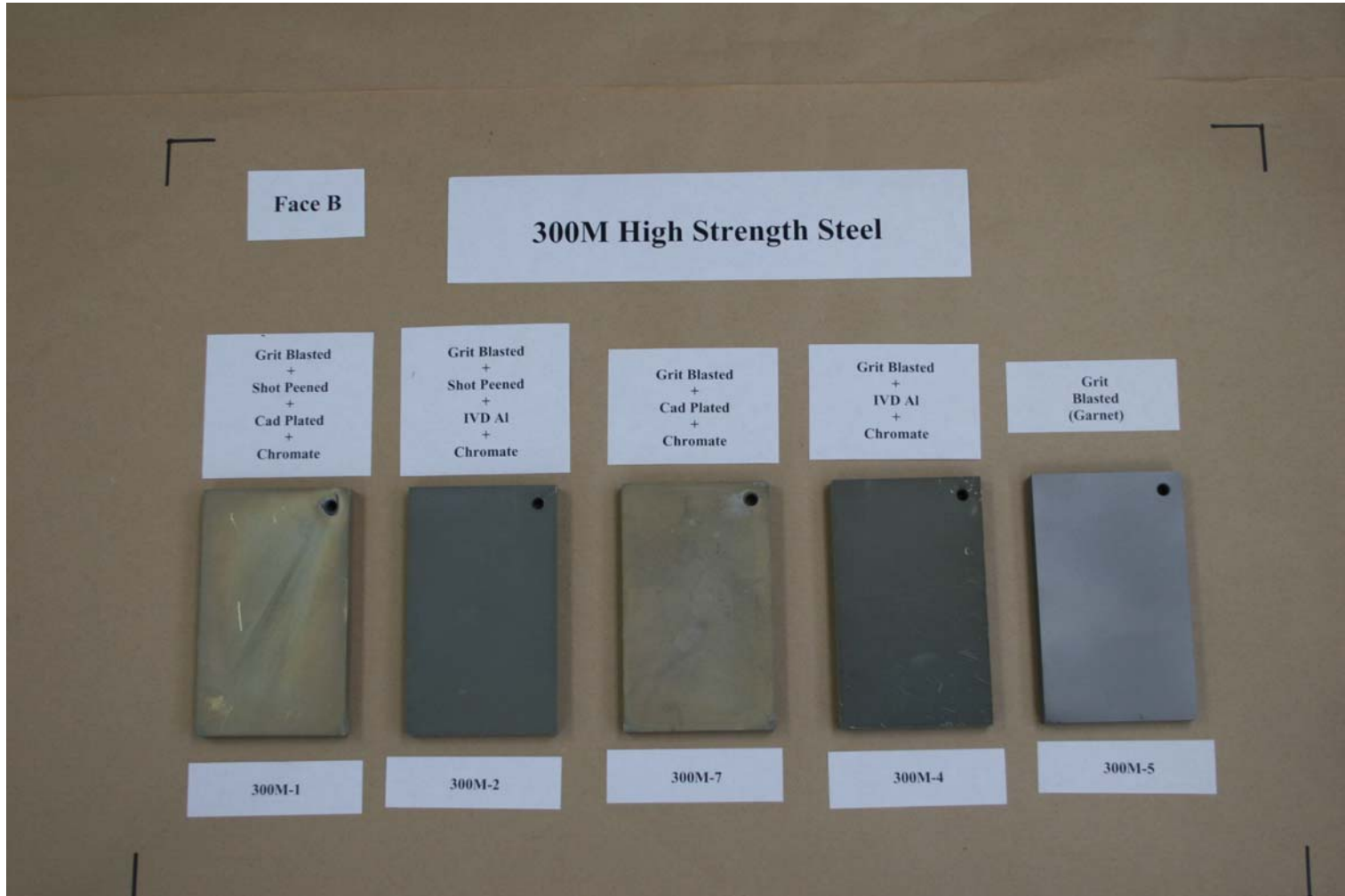


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Corrosion Testing

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Corrosion Testing



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TIFF (Uncompressed) decompressor
are needed to see this picture.

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S-53 Questions??



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