Propeller Component Project Update

Robert Kestler
Materials Engineer-Inorganic Coatings
Naval Air Depot Cherry Point, NC
# Propeller Component Project Update

**Abstract:** 24th Replacement of Hard Chrome Plating Program Review Meeting, July 20-21, 2004, Park City, UT. Sponsored by SERDP/ESTCP.

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**Performing Organization:**
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- Project Number:
- Grant Number:
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- Program Element Number:
- Task Number:
- Work Unit Number:

**Supplementary Notes:**
P-3/C-130
Barrel & Pin Assembly
P-3/C-130
Barrel & Pin Assembly
P-3/C-130
Lever Support Sleeve

Cr-Plated LPSLS

WC-Co Coated LPSLS
Implementation Efforts at Depots

- HVOF systems installed at NADEP Cherry Point
- Warner-Robins ALC installation complete
- Fixtures developed
- Grinding training
- Manual changes
- Joint process instruction
Qualification of Depots

- Process procedures will be submitted
- Each facility submits booth/procedure qualification samples
  - Metallographic samples
  - Almen coupon
  - Tensile bond buttons
  - Bend Test
- Each facility will coat a representative part or shape to be tested for residual stress in coating
Program Milestones

- Fatigue Testing - completed April 2001
- Wear - completed April 2001
- Corrosion - completed January 2001
- TCLP - completed January 2001
- Low Pitch Stop Lever Sleeve Component Test
  - Chrome plated - completed August 2001
  - WC-17Co - completed September 2001
Future Program Milestones

- Full Scale Engine Test of P-3 Hub at HS - Aug. 2002
- Completed Materials JTR - June 2002
- NADEP JAX based P-3 Operational Test - Nov. 2002
- Developing Joint Depot Operating Procedure - February 2003
- Operational JTR complete - November 2003
Summary Of Fatigue Tests

• WC-Co exhibited a 10% reduction in strength at low cycle stresses, and a 5% reduction in strength at high cycles stresses when applied 0.010 inches thick to AISI 4340 HRC 40-44
• Coatings thinner than 0.010 inches exhibited less fatigue strength debit on AISI 4340 HRC 40-44
• WC-Co exhibit superior fatigue properties to both EHC and T-800
• Shot peening had a negligible effect on the fatigue strength of WC-Co and T-800
Summary of Wear Tests

- The counterface specimen’s wear performance ranking was steel, copper, then Viton based on wear coefficients.
- WC-Co coating produced similar or lower wear rates on all counterface specimen materials when compared to EHC plating.
- The panel specimen’s wear performance ranking was WC-Co, Tribaloy T-800, then EHC plating based visual ranking of coating performance.
- WC-Co-Cr coating outperformed Electrolytic Hard Nickel plating in both coating visual ranking after test and counterface wear rate.
Steel Wear Rate Comparison
Based on Mass Loss Measurements

<table>
<thead>
<tr>
<th>Test Condition</th>
<th>Chrome Plate</th>
<th>Tungsten Carbide</th>
<th>Tribaloy T-800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low/Dither</td>
<td>0.0E+0</td>
<td>50.0E-14</td>
<td>1.0E-12</td>
</tr>
<tr>
<td>High/Long</td>
<td>1.0E-12</td>
<td>1.5E-12</td>
<td>2.0E-12</td>
</tr>
<tr>
<td>High/Long/SF</td>
<td>50.0E-14</td>
<td>0.0E+0</td>
<td>0.0E+0</td>
</tr>
<tr>
<td>Low/Dither/C</td>
<td>-1.0E-12</td>
<td>-1.5E-12</td>
<td>-2.0E-12</td>
</tr>
<tr>
<td>Low/Long/C</td>
<td>-50.0E-14</td>
<td>-1.0E-12</td>
<td>-1.5E-12</td>
</tr>
<tr>
<td>High/Long/O</td>
<td>-100.0E-14</td>
<td>-1.5E-12</td>
<td>-2.0E-12</td>
</tr>
</tbody>
</table>

Heavy pitting and adhesion of panel coating on steel
Copper Wear Rate Comparison
Based on Mass Loss Measurements

Test Condition

- Low/Dither
- Low/Long
- Low/Long/SF
- Low/Dither/C
- High/Long/C
- High/Dither/O

Wear Coefficient

- Chrome Plate
- Tungsten Carbide
- Tribaloy T-800
Panel Wear from Copper Specimens

- Test Condition: Chrome Plate, Tungsten Carbide, Tribaloy T-800
- Wear Conditions: No Wear, Mild Wear, Moderate Wear, Heavy Wear, Pitting

- Bar chart showing wear levels across different test conditions.
Panel Wear Rate Coefficient Against Copper Counterfaces
Based on Wear Scar Profilometer Measurements

Test Condition

Wear Coefficient

Chrome Plate
Tungsten Carbide
Tribaloy T-800
Viton Wear Rate Comparison
Based on Dimensional Wear Scar Measurements

Test Condition

- Low/Dither
- High/Long
- High/Long/SF
- High/Dither/C
- Low/Long/C
- High/Long/O

Wear Coefficient

- Chrome Plate
- Tungsten Carbide
- Tribaloy T-800
Viton Wear Rate Comparison
Based on Dimensional Wear Scar Measurements

![Graph showing Viton wear rate comparison for different test conditions and materials.](image)
Panel Wear from Viton Specimens

Test Condition:
- Low/Dither
- High/Long
- High/Long/SF
- Low/Dither/C
- Low/Long/C
- High/Long/O

Wear Grades:
- No Wear
- Mild Wear
- Moderate Wear
- Heavy Wear
- Pitting

Materials:
- Chrome Plate
- Tungsten Carbide
- Tribaloy T-800
PTFE Wear Rate Comparison
Based on Mass Loss Measurements

Test Condition

- Clean Oil
- Contaminated Oil

Wear Coefficient

<table>
<thead>
<tr>
<th>Hard Nickel</th>
<th>Tungsten Carbide Cobalt Chrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.0E-12</td>
<td>15.0E-12</td>
</tr>
<tr>
<td>35.0E-12</td>
<td>20.0E-12</td>
</tr>
<tr>
<td>40.0E-12</td>
<td>25.0E-12</td>
</tr>
</tbody>
</table>
Panel Wear from PTFE Specimens

- Pitting
- Heavy
- Moderate
- Mild Wear
- No Wear

Test Condition:
- Clean Oil
- Contaminated Oil

Adhesive / Abrasive Wear:
- Hard Nickel
- Tungsten Carbide Cobalt Chrome
PTFE Friction Coefficient Comparison

- **Clean Oil**
  - Hard Nickel
  - Tungsten Carbide Cobalt Chrome

- **Contaminated Oil**
  - Hard Nickel
  - Tungsten Carbide Cobalt Chrome
Summary of Corrosion Tests

- Nickel Plating was the overall top performer
- WC-Co-Cr was marginally the best HVOF coating
- Quantitative results based on the # of specimens from the B117 cabinet after 552 hours
  - Criteria - visible corrosion exceeding 0.3% of area
  - 66% as coated, 100% machined WC-Co pulled
  - 55% as coated, 100% machined T-800 pulled
  - 55% as coated, 55% machined WC-Co-Cr pulled
  - 22% as coated, 25% machined Nickel pulled
Summary of TCLP Tests

- Spent Material Tested (WC-Co-Cr, T-400, T-800)
- Virgin Powder Tested (WC-Co-Cr, T-400, T-800)
- NOT HAZARDOUS WASTE
- In Connecticut Would Be Considered Non-Hazardous Regulated Waste
Low Pitch Stop Specimen

- Cylinder Coatings
  - WC-17Co
  - Chrome Plate (AMS 2406)
- Piston Ring
  - Leaded Tin Bronze
- Test Conditions
  - 75,000 Stroking Cycles = 10/flight, 1hr/flight, 7,500hrs before overhaul
  - Hydraulic oil (Mil-H-83282 or similar)
  - 310 psi oil pressure to accurate piston
  - 150°F oil temperature
Summary of Low Pitch Stop Test

- Cylinder Appearance
  - Chrome Plate - Appearance of wear on chrome plate but no significant adhesive wear or scoring
  - WC-17Co - Appears untouched
- Piston Ring Appearance
  - Chrome plate - Signs of use but no substantial wear
  - WC-17Co - Signs of use but no substantial wear
Summary of Low Pitch Stop Test

• Quantitative Results
  • Cr-Plate Surface Finish 2.7 Ra at start, 1.4 Ra at completion
  • WC-Co Surface Finish 7.2 Ra at start, 7.2 Ra at completion
  • Ring weight loss 3 times higher with Cr plated bore