

EA-6B HVOF-Coated Landing Gear: Post-Deployment Inspection Results

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Outline

- Background
- HVOF Procedure
- Previous Results
- EA-6B Results
- Future Work



Background

- Electrolytic hard chrome (EHC)
 - Wear resistance
 - Corrosion resistance
- Uses hexavalent chromium (Cr^{6+})
 - Carcinogen, OSHA controlled
 - Expensive to dispose



Background

- IPT's for chrome alternatives
 - HCAT: Hard Chrome Alternatives Team
 - ESTCP: Environmental Strategic Technology Certification Program
 - JG-PP: Joint Group on Pollution Prevention
- Validation Project: HVOF Thermal Spray
 - Environmentally acceptable
 - Superior performance to EHC

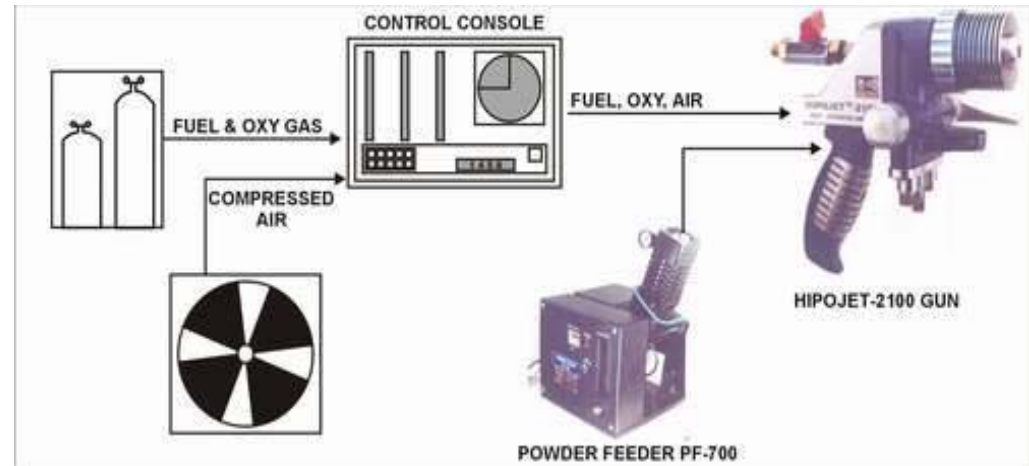
Background

- High Velocity Oxygen Fuel (HVOF)
 - Environmental Coatings
 - Wear Resistant Coatings
- FRCSE Applications
 - F404, F414, J52, TF34
 - Drive shafts, combustor cans



HVOF Procedure

- HVOF Process
 - Combustion of fuel gas and oxidizer (accelerant gas)
 - Feed powder into supersonic gas stream
 - Impact particles onto surface with high temperature and high velocity



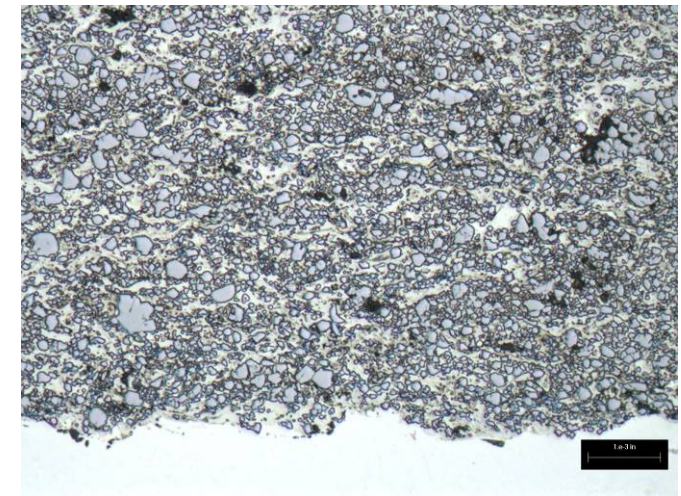
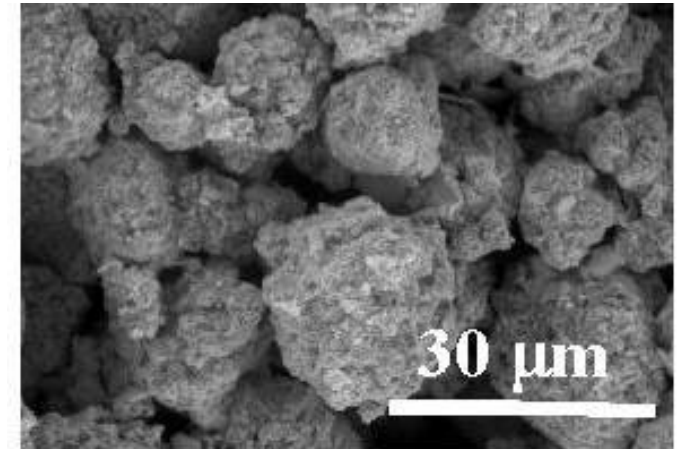
HVOF Procedure

- HVOF Advantages
 - Low porosity
 - High hardness
 - High adhesive bond strength
 - Higher density
- Fits into NAVAIR LEAN Processes
 - Increases throughput
 - Decrease turn around time
 - Reduce costs and simplifies work processes



HVOF Procedure

- HVOF Coating
 - METCO DIAMALLOY 2005 NS
 - 83WC-17Co powder mixture
 - Advantages over EHC
 - Hardness
 - Wear Resistance
 - Fatigue Resistance



HVOF Procedure

- Concerns for HVOF
 - Unknown response for:
 - Carrier-based landings
 - Saltwater corrosive environments
 - Coating susceptible to aqueous and gaseous corrosion
 - Require validation and demonstration in actual naval environments

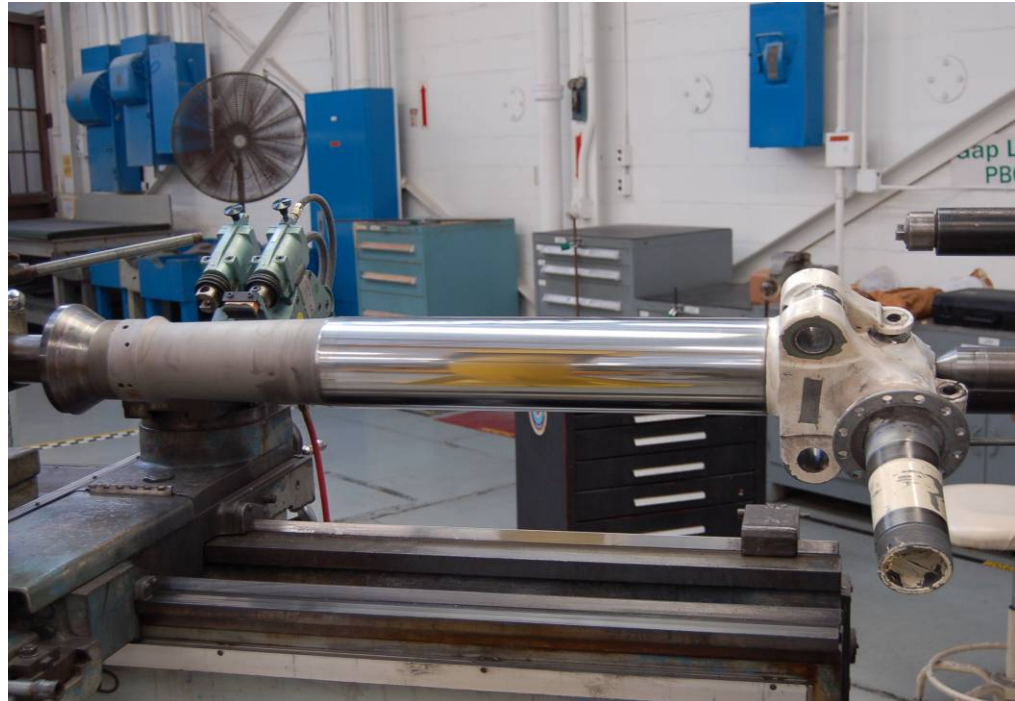
Previous Work

- Timeline
 - 10/1999: EA-6B Landing Strut HVOF coated
 - Spalling issues
 - High strains at large stresses
 - Flight clearance on hold
 - 09/2004: EA-6B successfully landed on USS Carl Vinson
 - HVOF coating successful
 - Major project milestone



EA-6B Landing Gear

- Current Landing Gear Strut Piston
 - AISI 4330 V Mod
 - $\sigma_Y = 180-185$ ksi
 - $\sigma_{UTS} = 220-240$ ksi
 - Coated
 - METCO DIAMALLOY 2005 NS
 - Ground finished
 - $Ra = 8-16$ μ in
 - Superfinished
 - $Ra = 2-4$ μ in



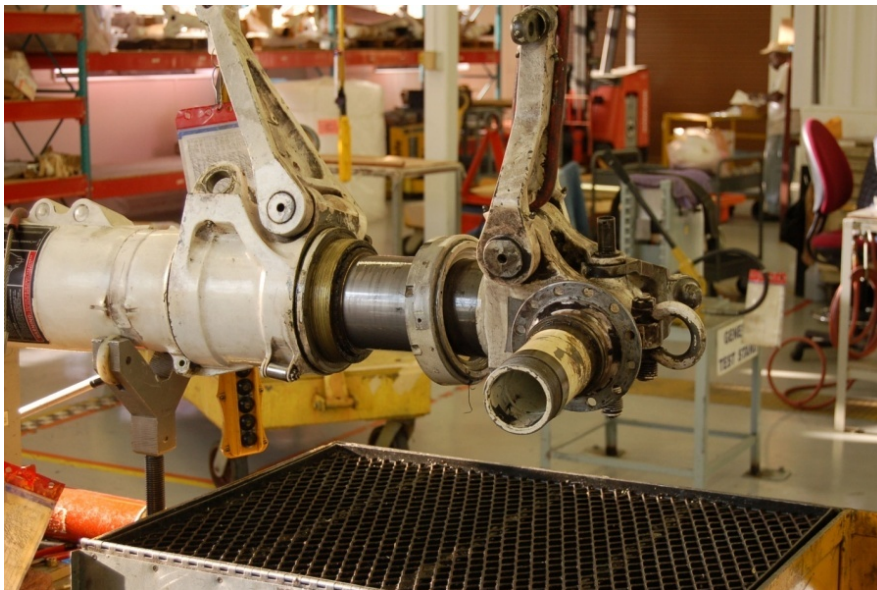
EA-6B Results

- EA-6B (163395) Tours of Duty
 - 2004-2005 VAQ 138/142
 - 2005-2009 VAQ 209 (Reserve Squad)
- Relatively short time-at-sea
 - 153 Catapult shots
 - 154 Arrested landings

Year	Flight Hours	Landings
2004	33	10
2005	605	207
2006	543	177
2007	192	85
2008	109	54
2009	70	38
Total	1552	571

EA-6B Results

- Strut Disassembly
 - Performed due to leak in lower seal



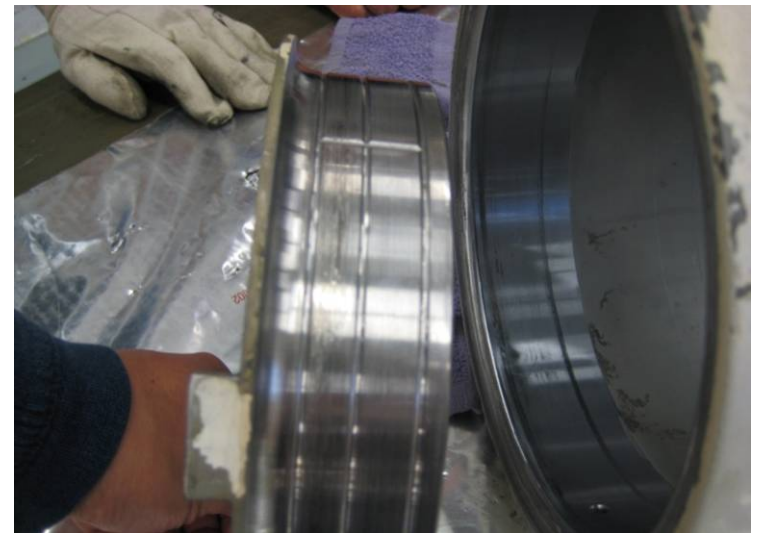
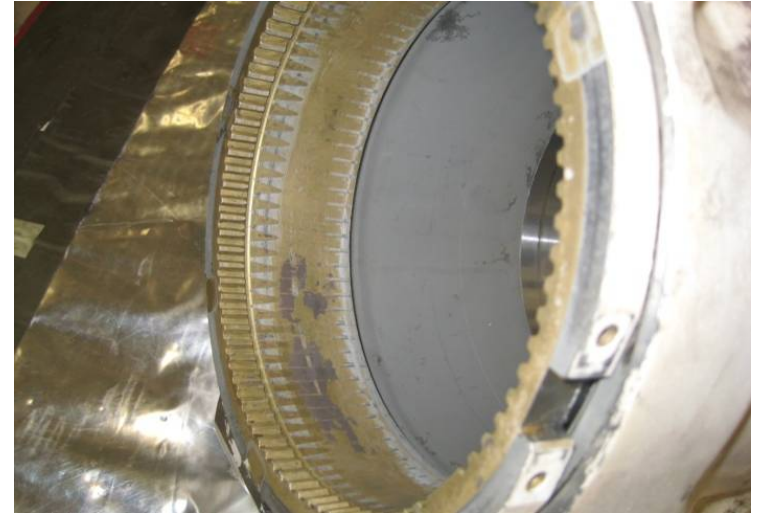
HVOF coated axle and piston
during tear down



HVOF coated piston during
disassembly

EA-6B Results

- Collar Assembly
 - No indications of wear or other damage



EA-6B Results

- Collar Assembly
 - Roughness check

HVOF coated area

Surface finish $R_a = 7 \mu\text{in}$;
 $R_a = 10\text{-}11 \mu\text{in}$ at outer most
edge shown

Chrome plated area

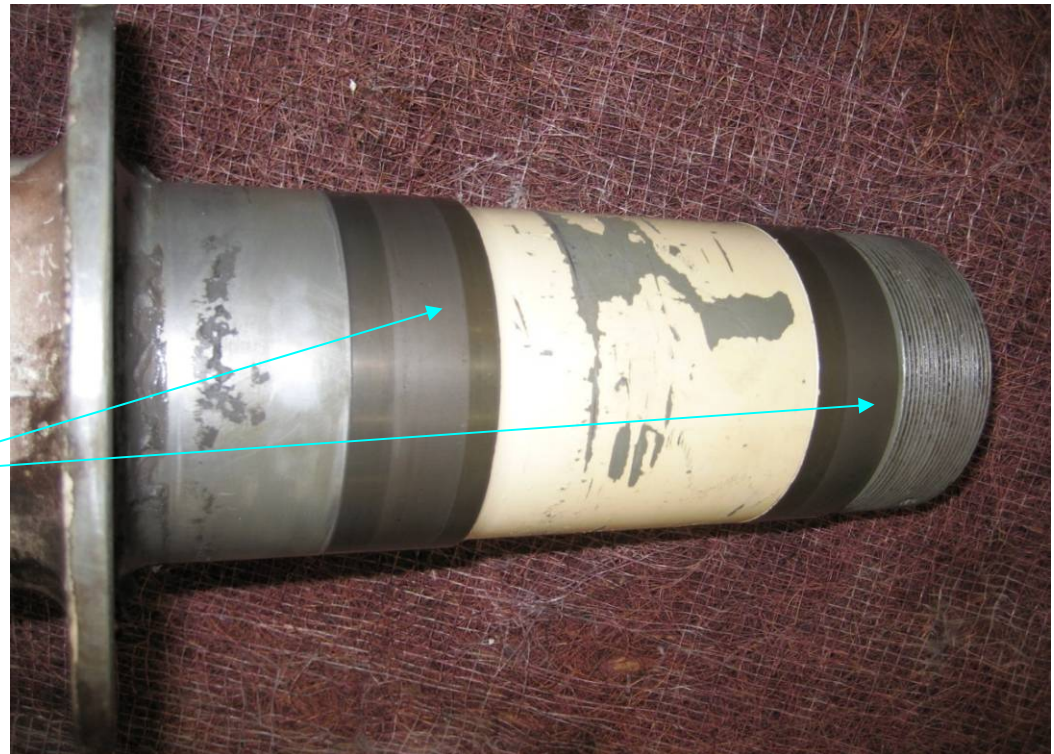
Surface finish $R_a = 6\text{-}7 \mu\text{in}$



EA-6B Results

- HVOF Axle

HVOF on Axle Journals, edges in good condition, coating appeared to be in very good condition



EA-6B Results

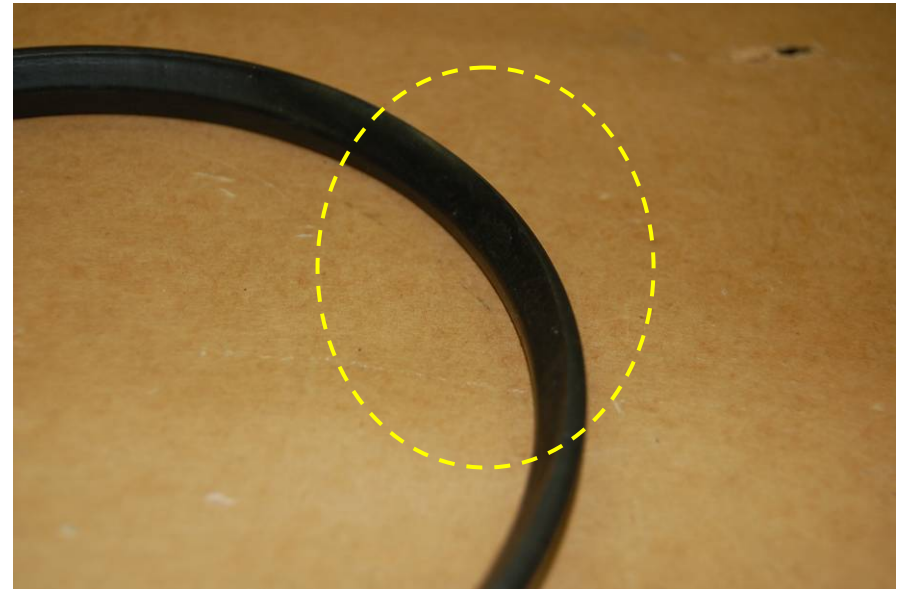
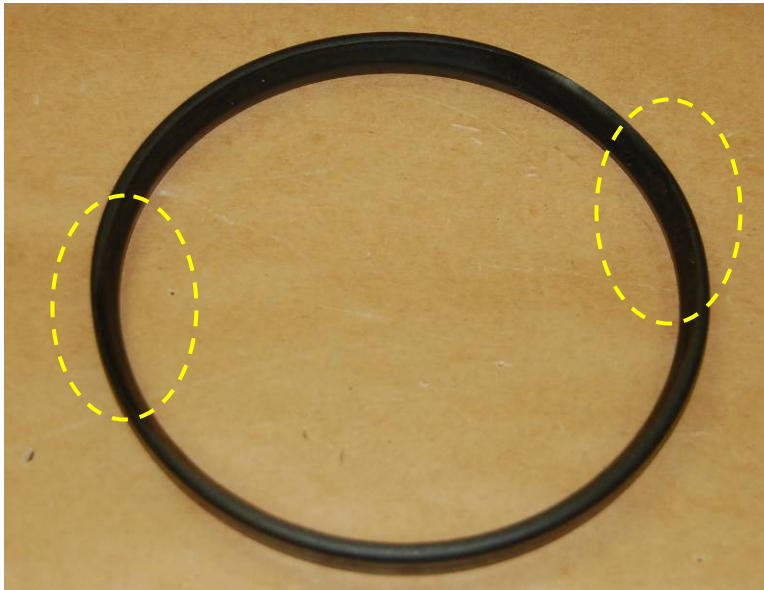
- Collar Bushing
 - The original item was discarded after disassembly
 - Operators reported part corroded
 - Corrosion typical for this part in service.



EA-6B Results

- Failed Seal

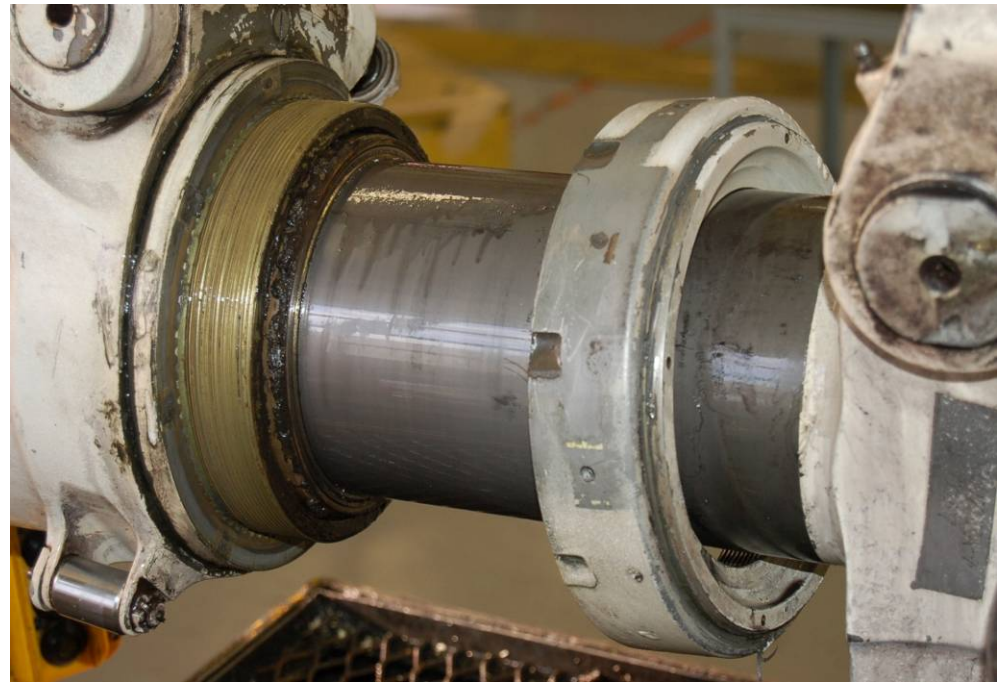
- Seal wear (“flat spots”) at 0° and 180°
- Possible service in Middle East: sand entrapment / intrusion issues
- Failure analysis will be performed by Trelleborg Sealing Solutions (POC: John Nash)



EA-6B Results

- Strut Disassembly - Barrel

- Visual Inspection
 - Roughness Check
- Clean
- Vapor Degrease
- Fluorescent Penetrant Inspection (FPI)
- Re-superfinish
 - Recheck roughness



Disassembly of collar and seal retainer in location of leak

EA-6B Results

- HVOF Piston Surface
 - Roughness check

Surface finish measured Ra 3-4 μin

Surface finish Ra 8-10 μin in center section

Surface finish measured Ra 11-18 μin in area 2" to 8" from base



EA-6B Results

- HVOF Piston Surface
 - Upper Seal Area



Finish Roughness (Ra) = 2-3 μin



EA-6B Results

- HVOF Piston Surface
 - Lower Seal Area



EA-6B Results

- Corrosion issues
 - FPI initially found no indications
 - After superfinishing, pits found in the coating
 - Co binder highly susceptible to salt corrosion



Future Work

- First/Best option: Keep Current Coating
 - Re-superfinish current pitted HVOF coating
- Goal: Remove pits, establish Ra of 2-4 μin
 - Want coating thickness above minimum tolerance
 - If not, then part is in a state of Functionally Unusable Component Technology

Future Work

- **Second/Last option: Apply New Coating**
 - Grind pitted coating to parent metal
 - Recoat the part to return to service
 - Apply chrome coating -OR-
 - Reapply HVOF coating
- **Complications**
 - Future HVOF coating choice
 - DIAMALLOY 2005: 83WC-17Co
 - AMDRY 5843 (AMS 2447-9): 86WC-10Co-4Cr
 - FUNDING!?!
 - *“Hubba, hubba, hubba, money, money, money...who do you love?”*



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 - EA-6B FST Engineer, FRCSE 43310



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 - HVOF Program Manager, ES3

Questions?



Due to NAVAIR restrictions, responses to questions are not authorized.