

Hydraulic Actuator Project

- *Stakeholder meeting held 7-8 October in Los Angeles; 58 attendees representing aircraft and actuator OEMs, seal manufacturers, Air Force and NAVAIR cognizant authorities, HCAT, Caterpillar and thermal spray vendors*
- *Recent activities reviewed and then draft Joint Test Protocol discussed and revised*
- *JTP divided into two parts:*
 - *Part I: Coupon Testing*
 - *Part II: Functional Rod/Seal Testing*
- *Keith Legg prepared latest versions resulting from meeting*

Report Documentation Page

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Actuator JTP: Coupon Testing

■ *Substrate materials to be evaluated:*

- *4340 steel (180-200 ksi)*
- *PH15-5 stainless steel (155 ksi)*
- *Ti-6Al-4V (130 ksi)*

■ *Coatings to be Evaluated:*

- *WC-20Ni7Cr6C (Praxair LW105)*
- *WC-10Co-4Cr (per BAC 5851, Type XVII)*
- *Cr₃C₂-25NiCr (per BAC 5851, Type XVI)*
- *Tribaloy 400 (per BAC 5851, Type XV)*
- *Another alloy coating (perhaps Ni-Ti shape memory alloy)*
- *Hard chrome plate per QQ-C-320 (not superchrome)*

■ *Tensile testing is to be conducted on substrate materials to verify properties*

Actuator JTP: Coupon Testing

■ Fatigue Testing

- Axial per ASTM 466-96, hourglass sample
- Environment: lab air and NaCl
- Coating thicknesses (after grinding): 0.003” and 0.010”
- $R = -1$; high load at 85% of yield; low load to give 1 million cycles; intermediate load

Table Error! No text of specified style in document.-1. Fatigue test matrix. (Note: identical matrix for each substrate alloy.)

Coating	Thickness (mil)	Environment	# of specimens 4340	# of specimens PH 15-5	# of specimens Ti 6Al4V
Uncoated		Air	20	20	20
Uncoated, unpeened		Air	20	20	20
EHC	10	Air	10	10	10
WC-CoCr	10	Air	10	10	10
WC-CrNiC	10	Air	10	10	10
Cr ₃ C ₂ -NiCr	10	Air	10	10	10
T-400	10	Air	10	10	10
Total			90	90	90
				Grand total	270

Actuator JTP: Coupon Testing

■ *Integrity Testing*

- *Hollow “big-bar” starting at 50% of yield strength and continuing up to 106% of YS or coating failure*
- *Four-point bend testing*

■ *Corrosion Testing*

- *ASTM B117 neutral salt fog*
- *ASTM G-85 sulfur dioxide*
- *ASTM G-71 (or alternative) galvanic*
- *Specimen shape: mostly 1” –dia. rods (grinding), some flats*

■ *Fluid Immersion*

- *Specimen shape: 1”-dia. Rods*
- *Tests to be conducted with approximately 12 different chemicals including hydraulic fluids, cleaners, etchants, fuels, and decontaminants*

Actuator JTP: Coupon Testing

- *Impact Testing*
 - *Gardner Impact (free-falling striker impacting on coating)*
 - *Gravelometry*
- *Environmental Hydrogen Embrittlement*
 - *ASTM F519 test (notched round bar)*
 - *4340 steel (280 ksi) and Ti-10-2-3*
 - *Test at 45% notch tensile strength in DI water and 5% NaCl solution*
- *JTP also includes quality control tests, appendices on coating process documentation, and Almen strip and temperature measurement procedures*

Actuator JTP: Rod/Seal Testing

- *Testing to be done on NAVAIR Pax River test apparatus (shown in next slide)*
- *Substrate rods fabricated from PH13-8Mo stainless steel (220 ksi)*
- *Coatings to be evaluated are basically same as for coupon testing, except nanocrystalline Co-P alloy coatings will be included*
- *Different surface finishes to be evaluated*
- *Mating seals to include elastomeric O-ring seals and spring-energized PTFE seals provided by different seal manufacturers*

Pax River Test Apparatus

Test apparatus mounted in environmental chamber; consists of four rods with pair of seal blocks per rod

Primary seals in blue, secondary seals in magenta; two seal configurations per block and 16 seal configurations under test

