

# P-3 HVOF Piston WC-Co Coating Analysis

**HCAT**  
**23 Jan 07**



U.S. AIR FORCE



Engineering & Software  
System Solutions Inc

**KAMATICS Corporation**



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# P-3 HVOF Strut



# P-3 Strut Service History

Table 1. HVOF MLG Shock Strut Service History			
P-3 R/H MLG Shock Strut Assembly P/N 937958-103, S/N C30-1252, HVOF Piston P/N 978536-103, S/N 703			
Date	Landings	Aircraft	Comments
26 Apr 99	0	156522	Installed at VP-30
01 Aug 99	850	156522	Removed due Non-HVOF related leak
25 Apr 01	850	160284	Installed on new Aircraft after JAX repair
23 Aug 01	1,078	160284	
13 Aug 03	2,858	160284	Aircraft to JAX for PDM
06 Feb 04		160284	Aircraft returns from JAX to VP-30
07 May 04	3,329	160284	
01 Mar 05	4,410	160284	
15 Jan 06	6,378	160284	Returned to Supply IAW AFB 383

# Teardown Review

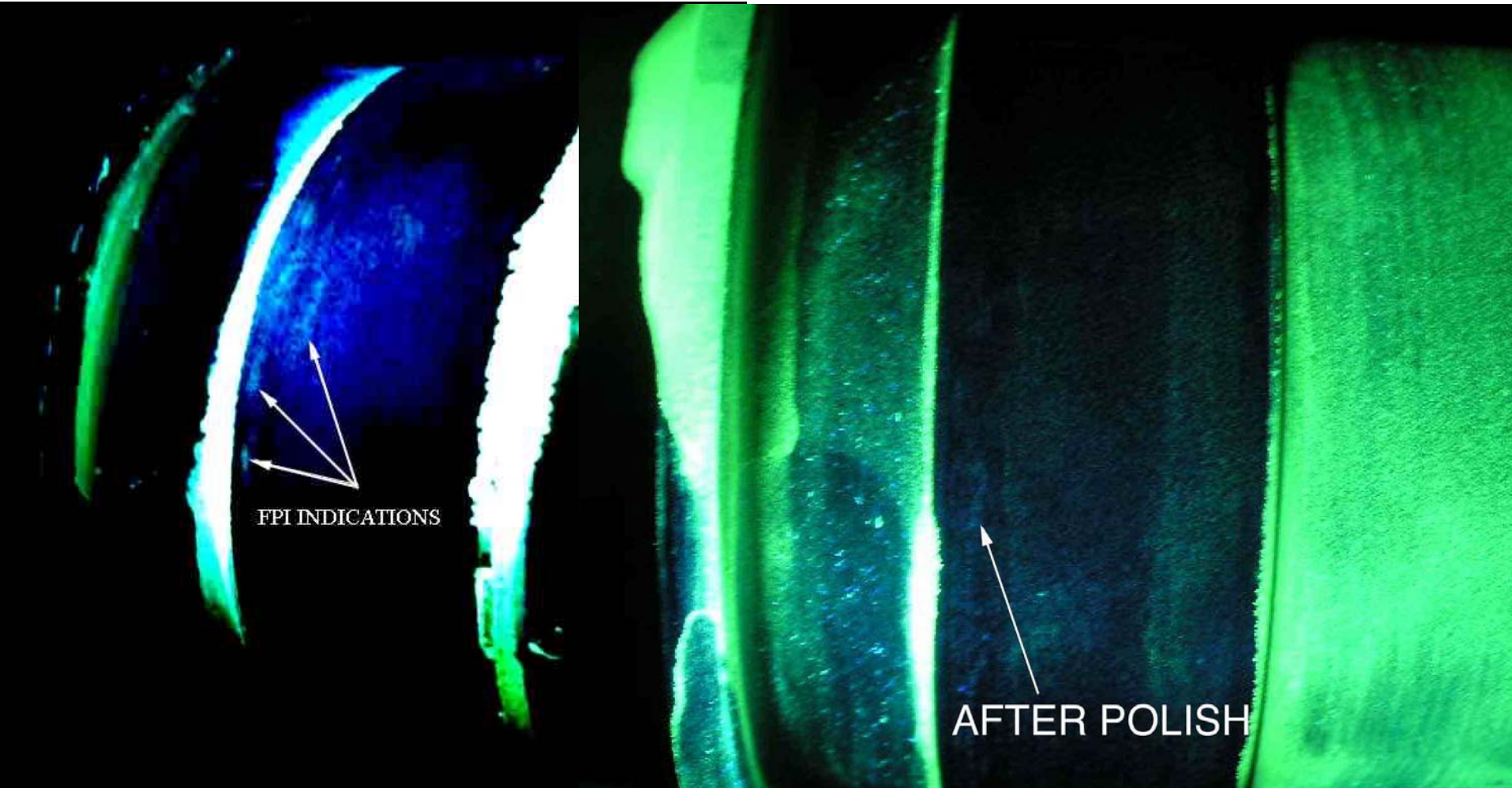
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- Teardown Heroux-Devtek
- Presented in A-5 Spring & Fall 06
- Barkhausen Indication Axle Journal
- FPI Indications (Journal & Barrel)
- Surface Roughness Changes (Barrel)
- Black Spots Visible (Barrel)

# Barkhausen Axle Journal



# FPI IB Axle Journals



# FPI Piston Barrel



FPI INDICATION



AREA AFTER POLISH

# Surface Roughness Inspection



# Surface Roughness Inspection

Table 4- P-3 Piston Axle Journal Surface Finish Results		
Journal ID	Forward Average Ra	Aft Average Ra
Left Outboard	8	6
Left Inboard	7	9
Right Outboard	5	8
Right Inboard	9	7

Table 5- P-3 Piston Barrel Surface Finish Results		
Barrel ID	Forward Average Ra	Aft Average Ra
Top	2	3
¼ Down	5	4
Middle	7	7
Static Position	12*	12*
Bottom	57	40

\* Area is "dirty" possible lower bearing phenolic material embedded.

# Surface Roughness Inspection

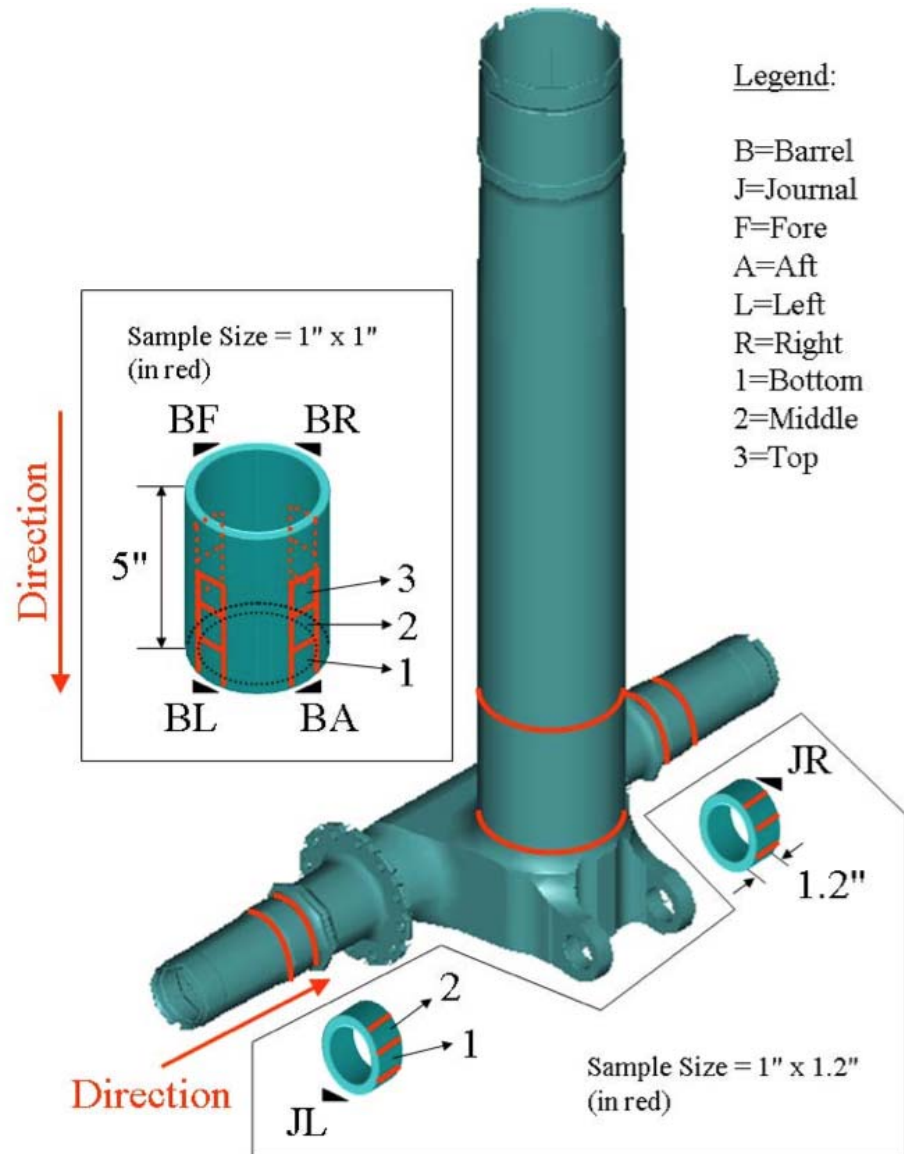


# Additional Coating Analysis

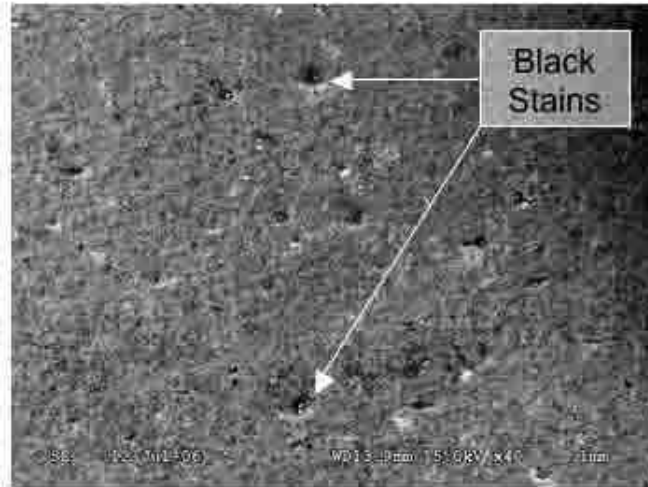
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- Coatings analyzed by Heroux Devtek
- Barkhausen indication axle journal
  - No burns- shot peen effect
- FPI indications (journal & barrel)
  - None after polish
- Surface roughness changes (barrel)
  - Phenolic bearing wear (Kamatics)
  - Packings normal (Greene Tweed)
- Black spots visible (barrel)
  - Details follow.....

# Additional Coating Analysis



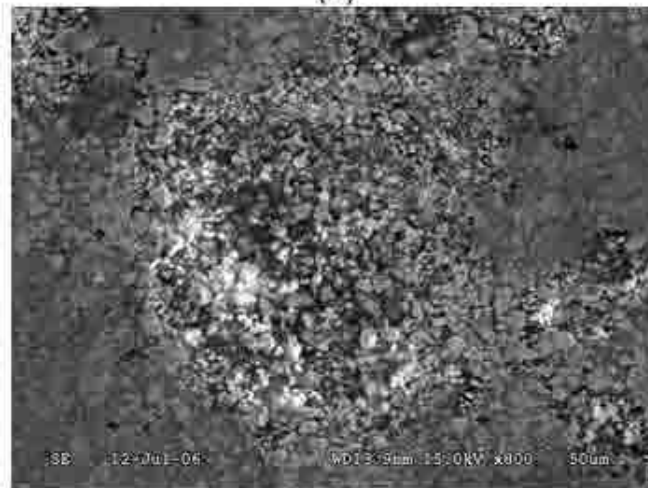
# Additional Coating Analysis



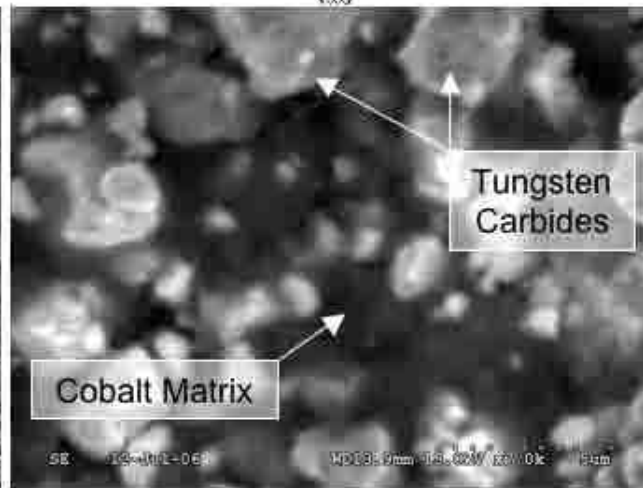
(a)



(b)



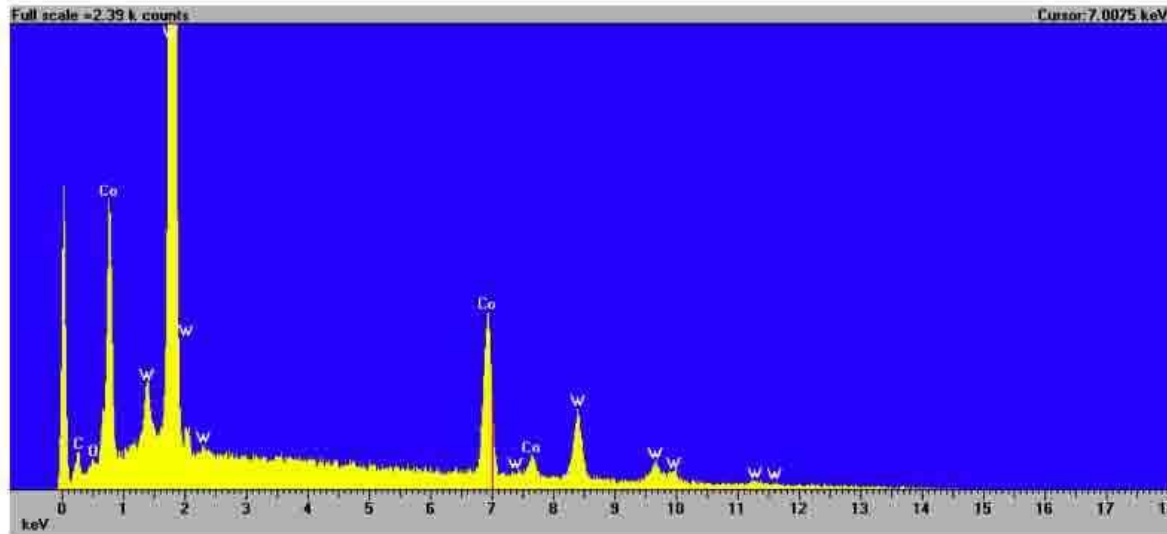
(c)



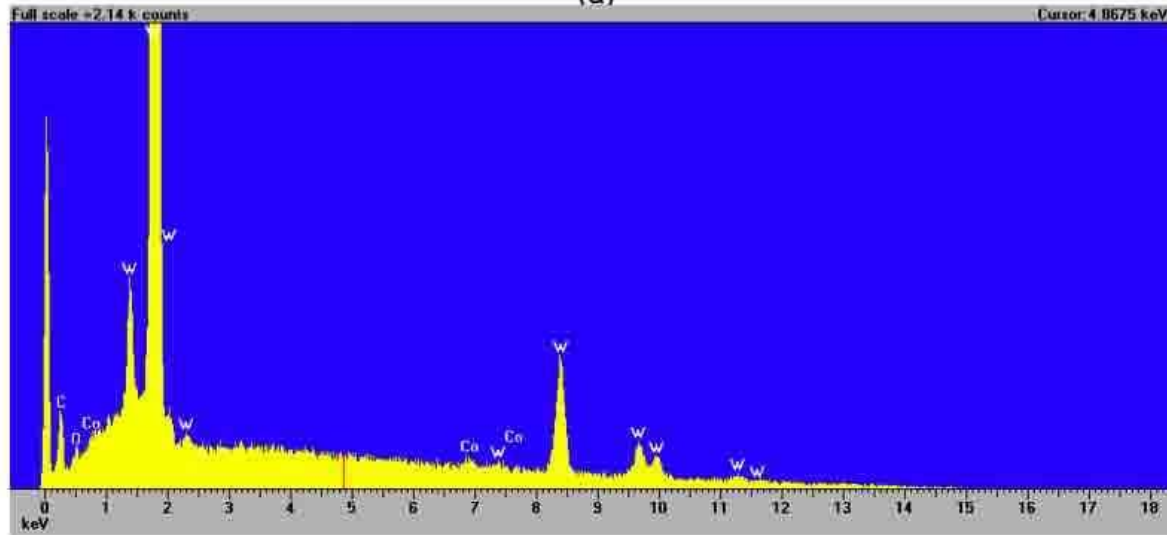
(d)

Secondary electron images of HVOF coating surface on the left side of the barrel OD: (a) x40, (b) x120, (c) x800 and (d) x7000 magnification.

# EDS Un-pitted Area



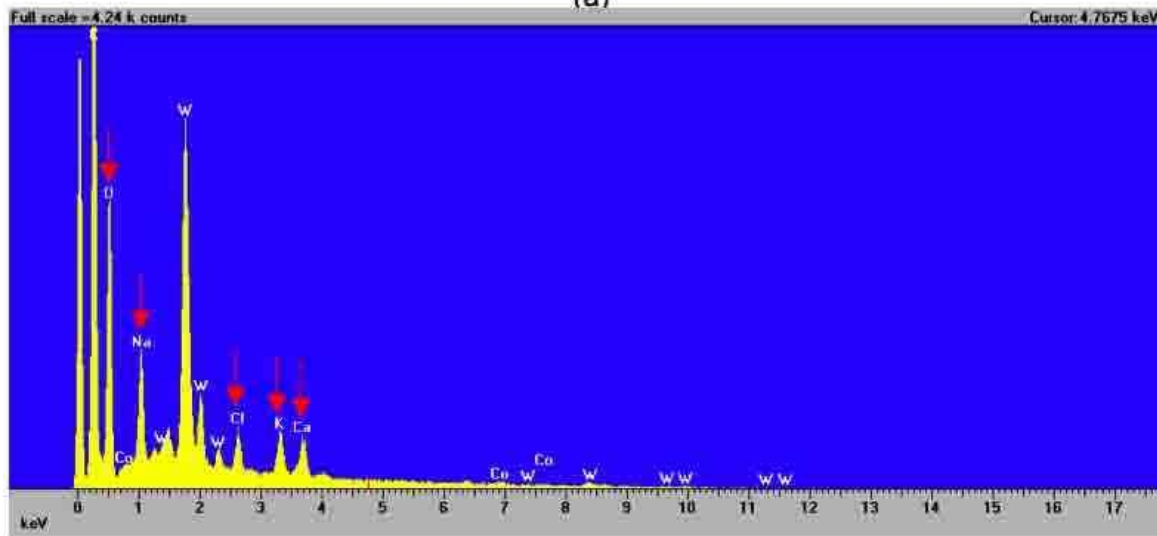
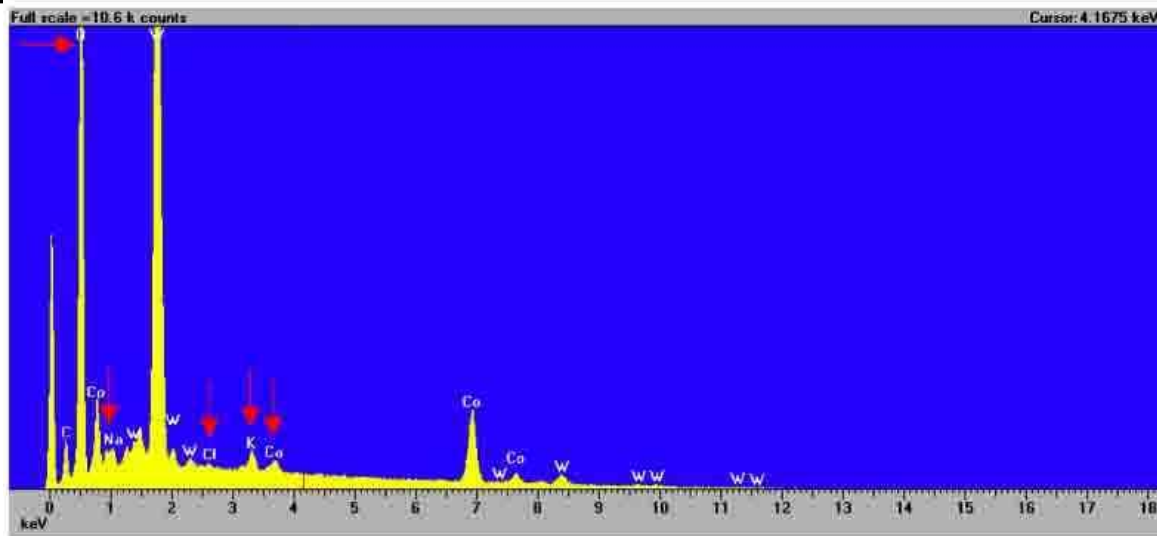
(a)



(b)

EDS x-ray spectra of unpitted area: (a) matrix and (b) carbide particle.

# EDS Pitted Area



EDS x-ray spectra of pits: (a) analysis of matrix and (b) carbide particle showing high peaks for O and the presence of Na, Cl, K and Ca (red arrows).

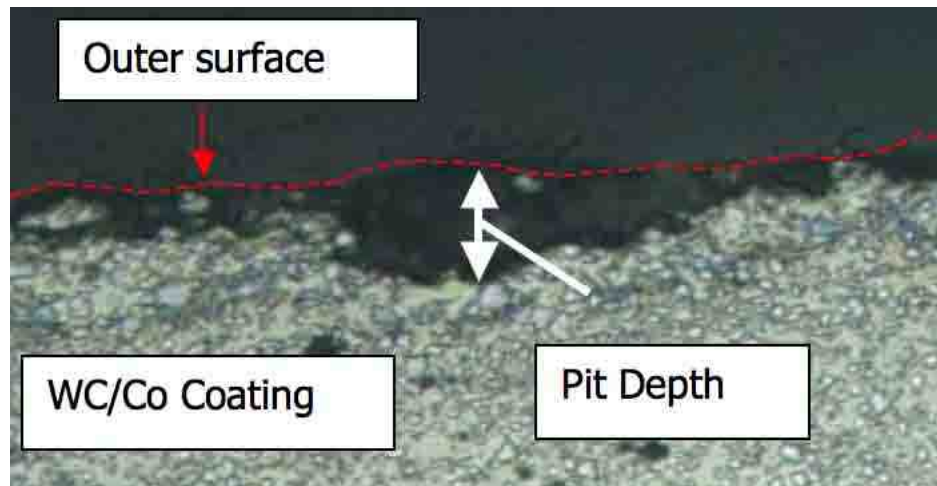
# Coating Analysis Results

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- Black spots are actually shallow pits
  - Selective leaching Co corrosive attack
  - Pit size
    - Larger/deeper than ave. HVOF porosity
    - Largest pits 10 mils dia. x 1.5 mils deep
  - EDS x-ray Spectra of pits
    - Na, Cl, K, Ca (seawater, cleaners)
    - O (corrosion bi-product)
- Axle journal “indications”
  - No indication remained after polish
  - No cracking found- coupons sectioned

# NADEP JAX Coating Analysis

- One set of coupons send to JAX
- Black spots Analysis supports HD
- WC Co corrosive attack
  - Pits Larger/deeper than ave. HVOF porosity



- Axle Journal
  - No cracks present

# Conclusions

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- HVOF coating degraded in service
  - Surface finish
  - Black spots (pits)
- Coating degradation didn't impact life
  - Superfinish during overhaul
  - Piston could have returned to service
- Possible improvements
  - Lined lower bearing
  - Lower bearing seal type/material
  - WC Co Cr in lieu of WC Co