HCAT

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HARD CHROME ALTERNATIVES TEAM

GTE Carbon Seal Test Results

HCAT Program Review

Park City, UT

July 2004

ROWAN TECHNOLOGY GROUP

Linking Global Technologies with Markets

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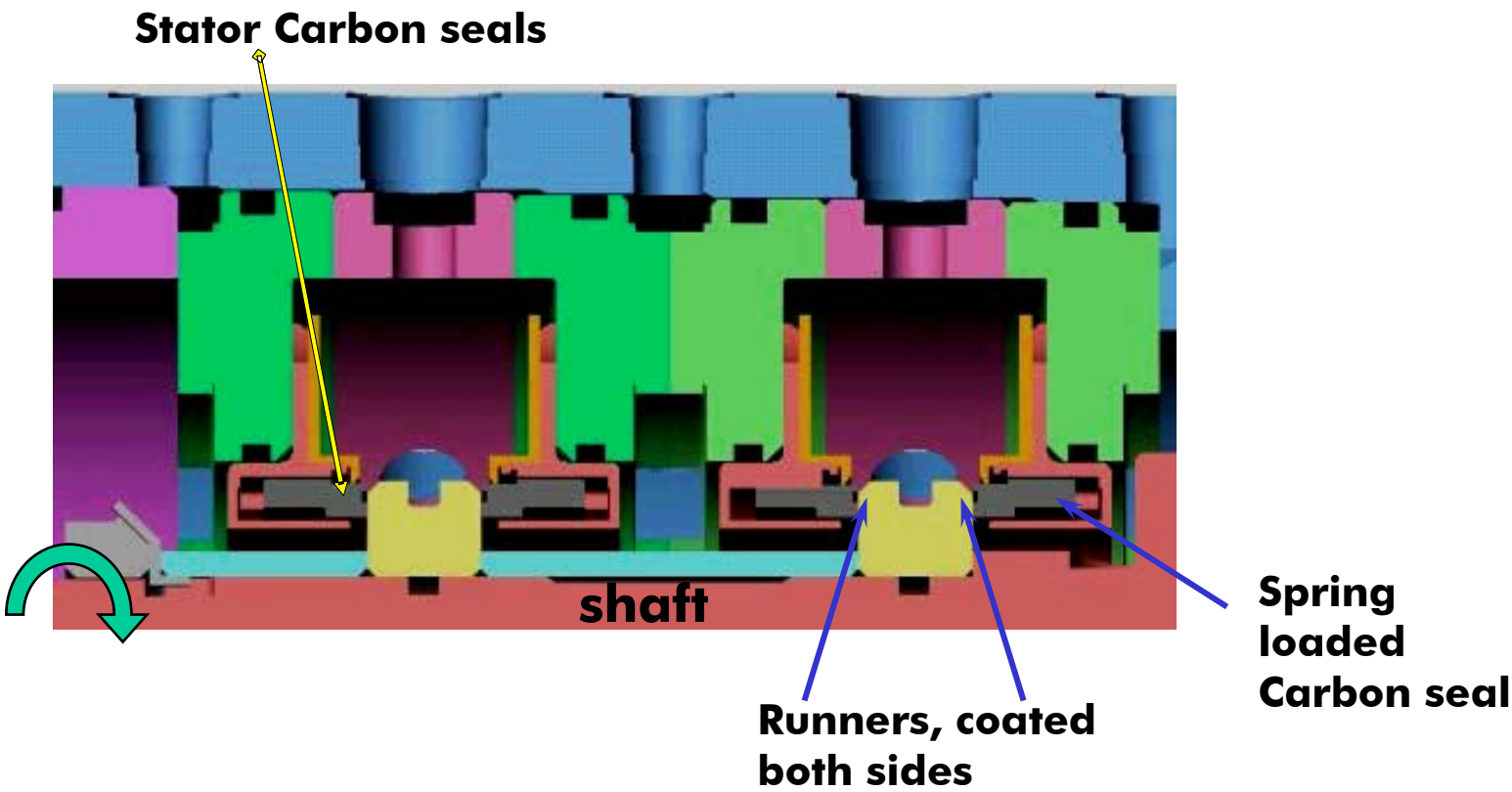
Test arrangement



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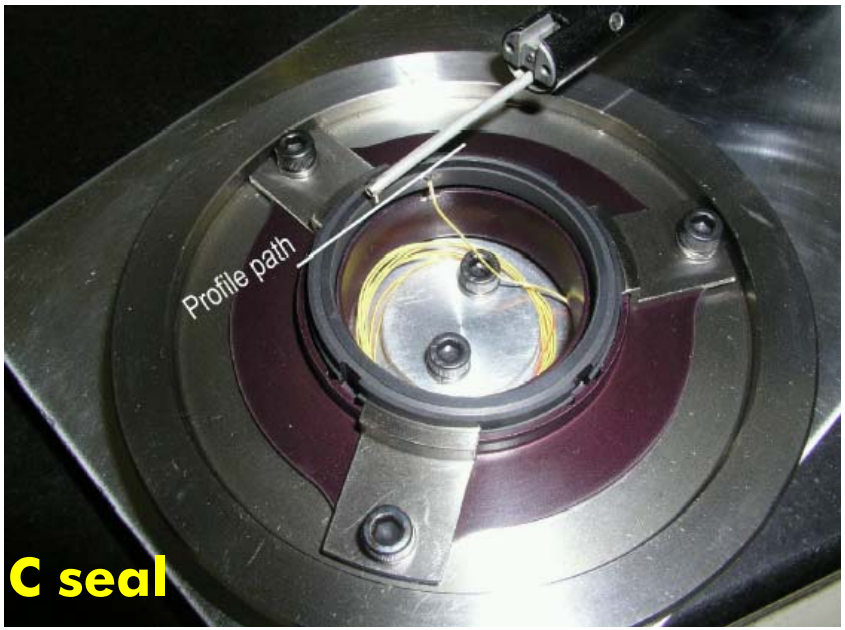
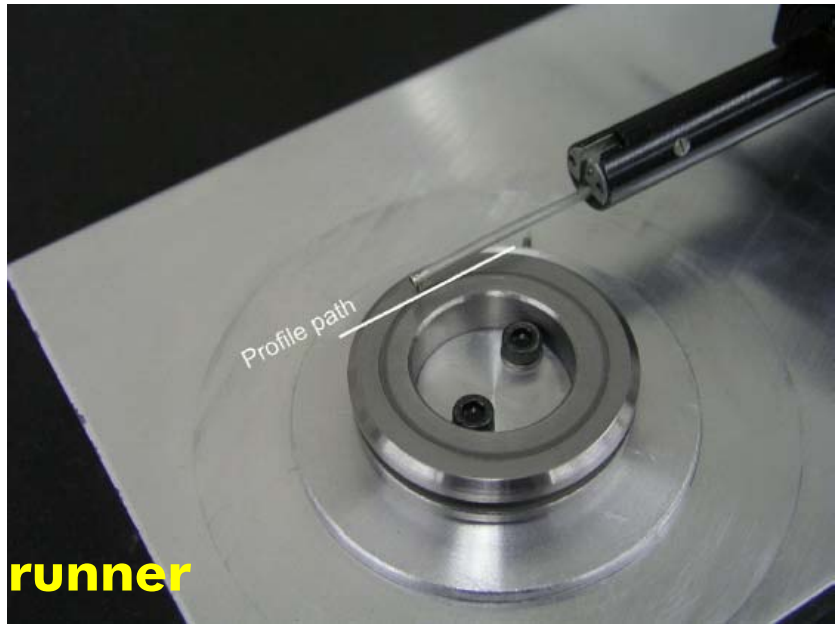
Wear measurement





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Test conditions

- **Carbon seal material**
  - **Graphitar 39**
  - **Graphitar 67**
- **Surface roughness**
  - **8Ra**
    - **Most testing done with this**
  - **4Ra**
    - **Found this is now more common spec**
- **Engine speed**
  - **7,000 rpm**
  - **13,500 rpm**
- **Coatings**
  - **EHC, WC-17Co, Cr_3C_2-NiCr, HVOF T400 & T800, APS T400, APS WC-17Co**

- **Tests run using a DOE method to avoid having to run full matrices**
- **Wear coefficient:**

$$K \equiv \frac{\delta}{t}\left(\frac{H}{pv}\right)$$

Wear depth"	Hardness (ksi)
Time (sec)	Pressure (ksi) x sliding velocity ("/sec

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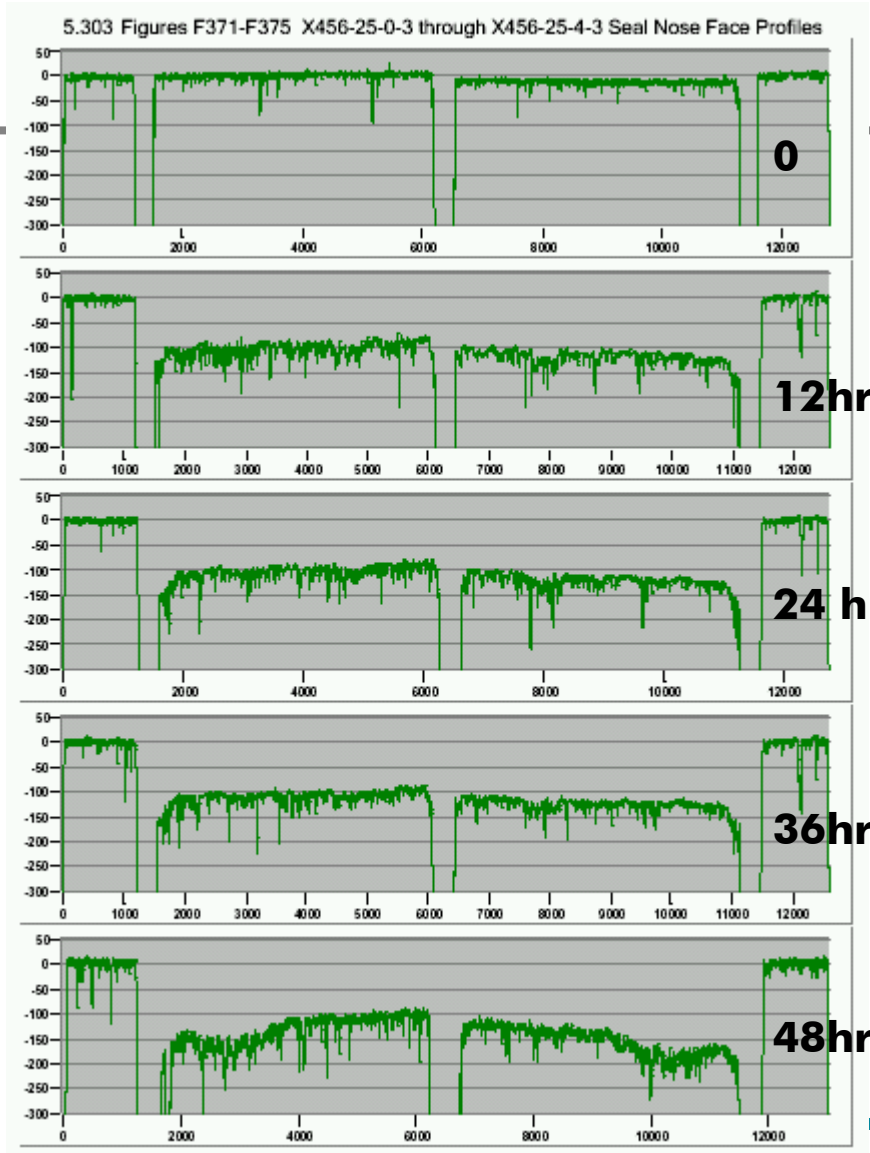
Wear of C seal

Wear happens



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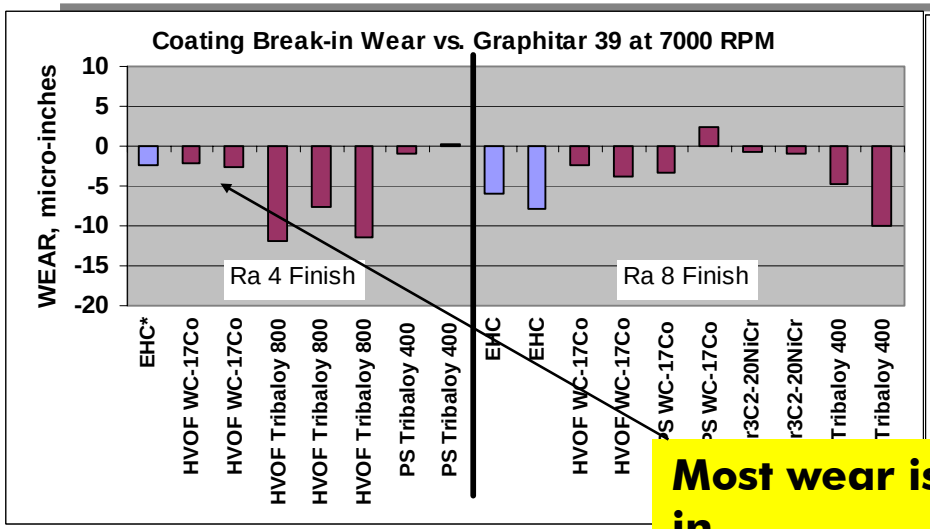
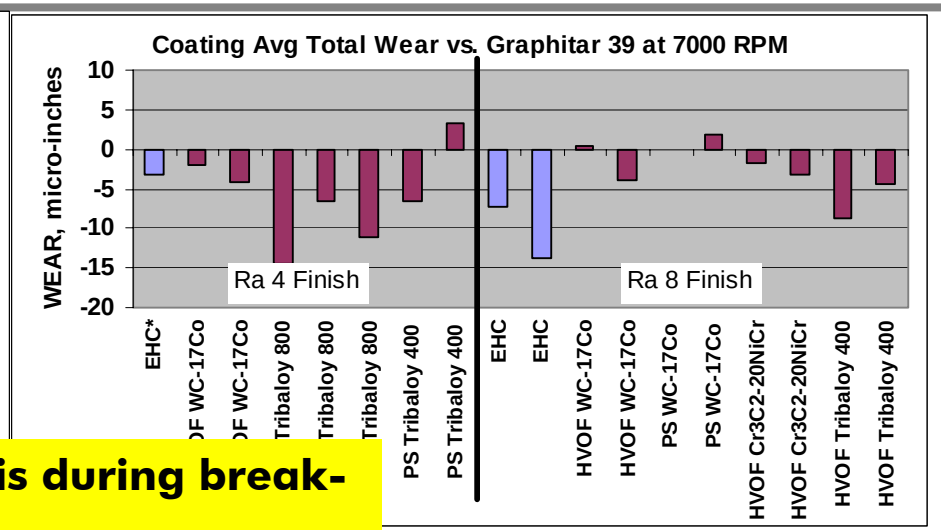
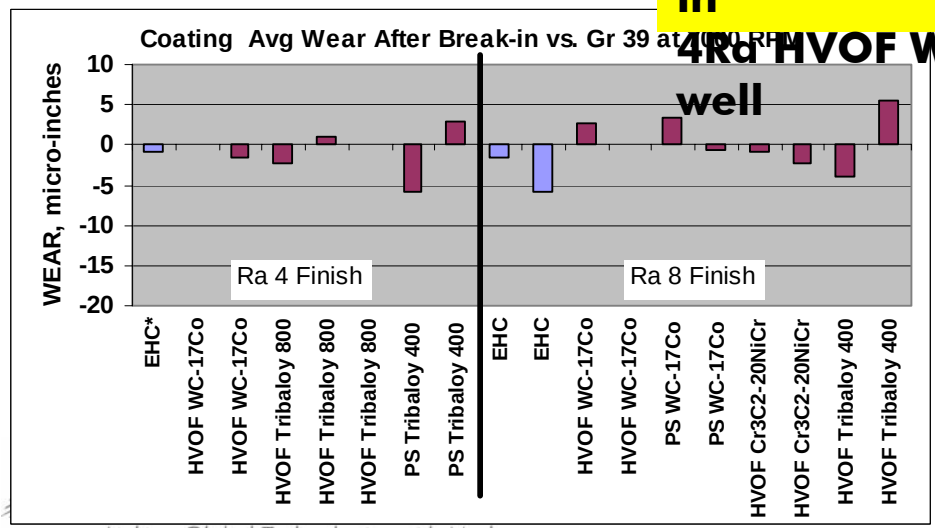
Wear of coating vs Graphitar 39 at 7,000 rpm

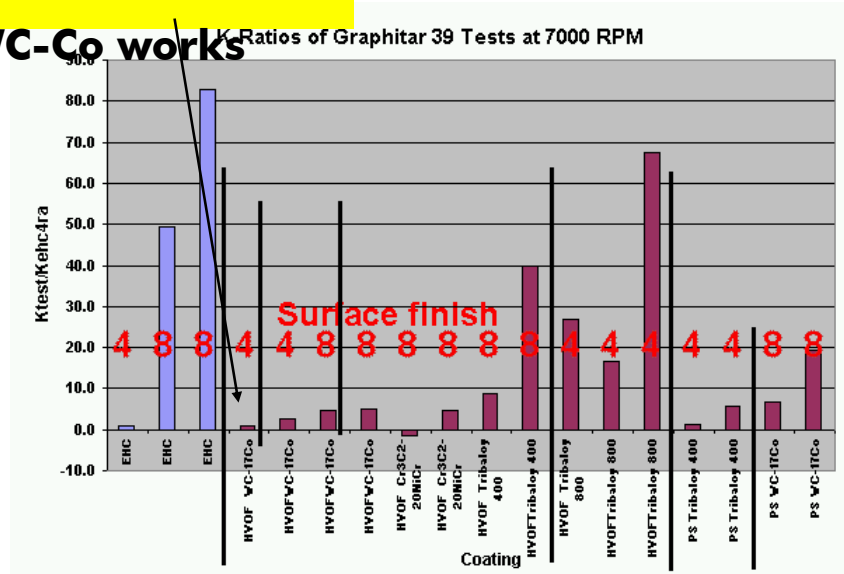




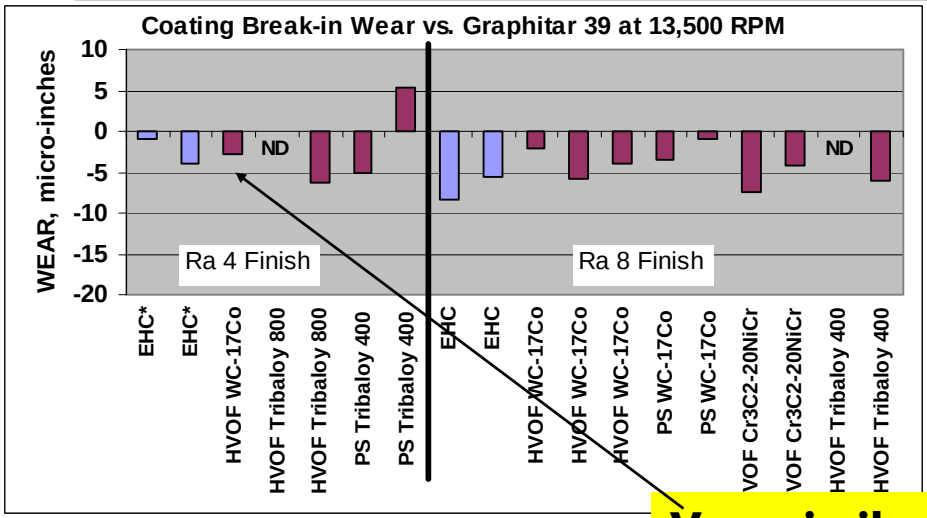
Most wear is during break-in

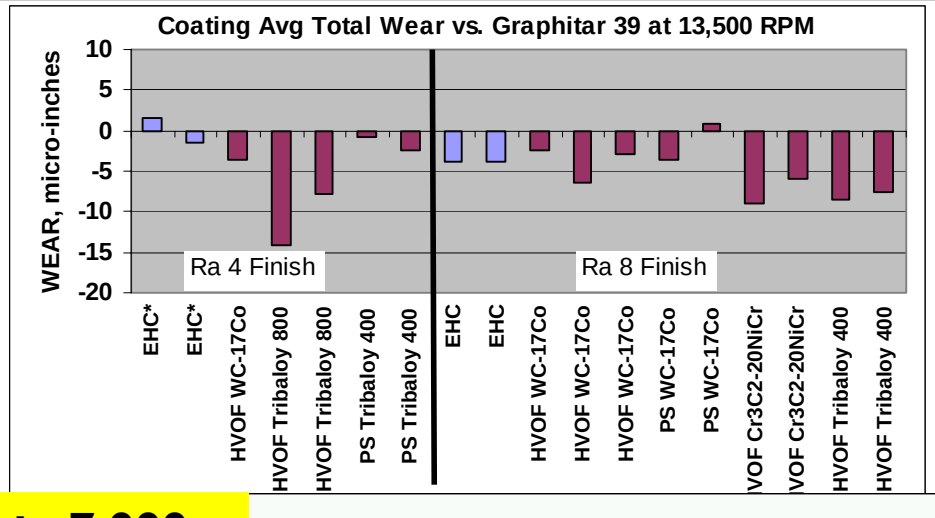
4Ra HVOF WC-Co works well



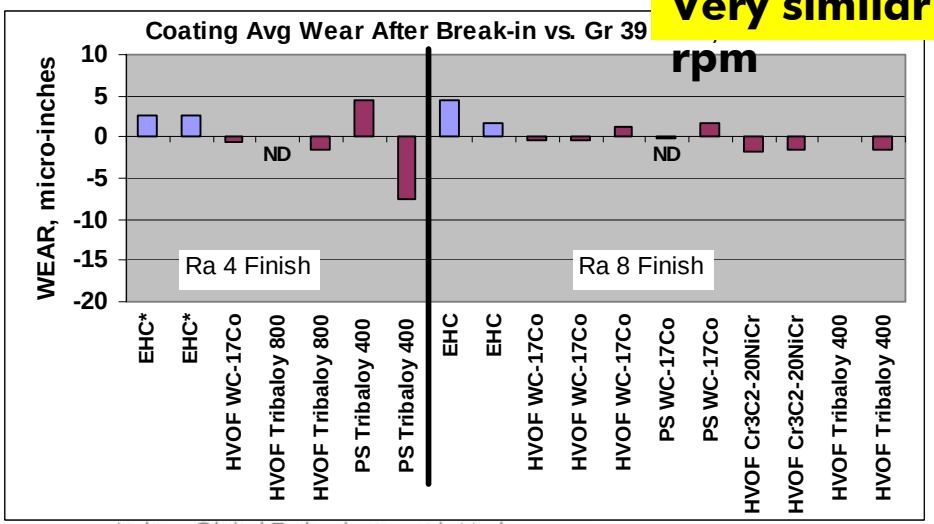


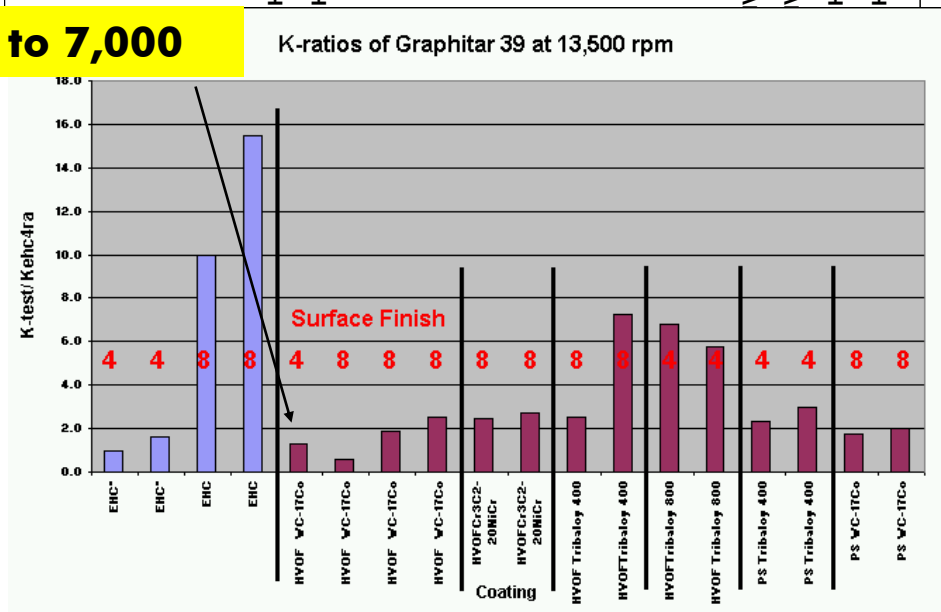
Wear of coating vs Graphitar 39 at 13,500 rpm



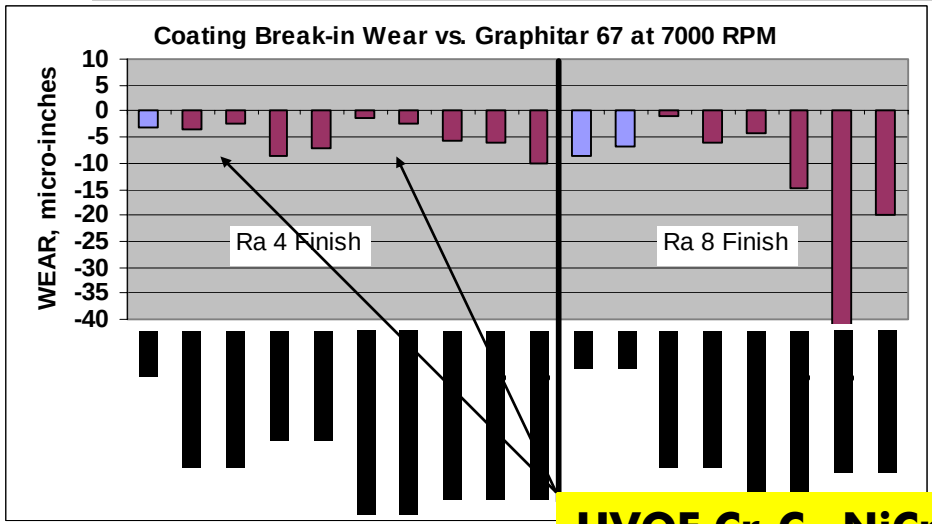


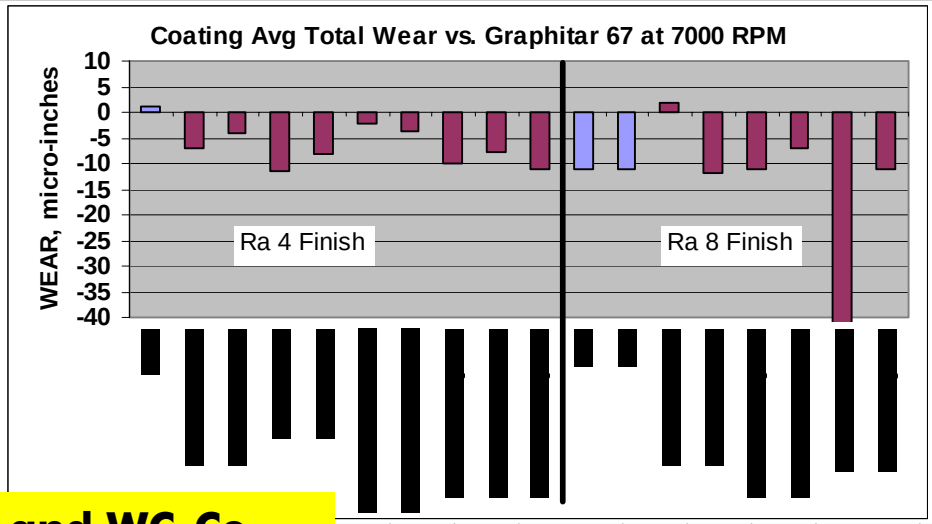
Very similar to 7,000 rpm



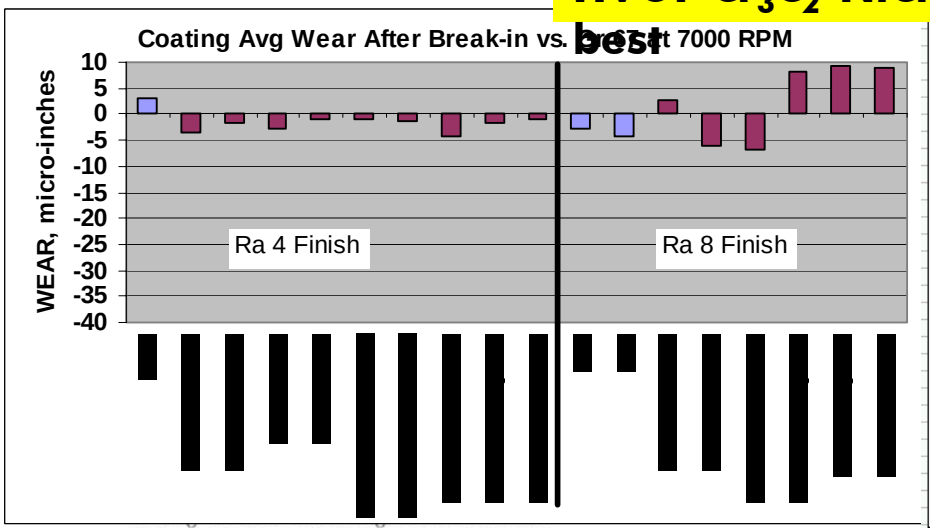


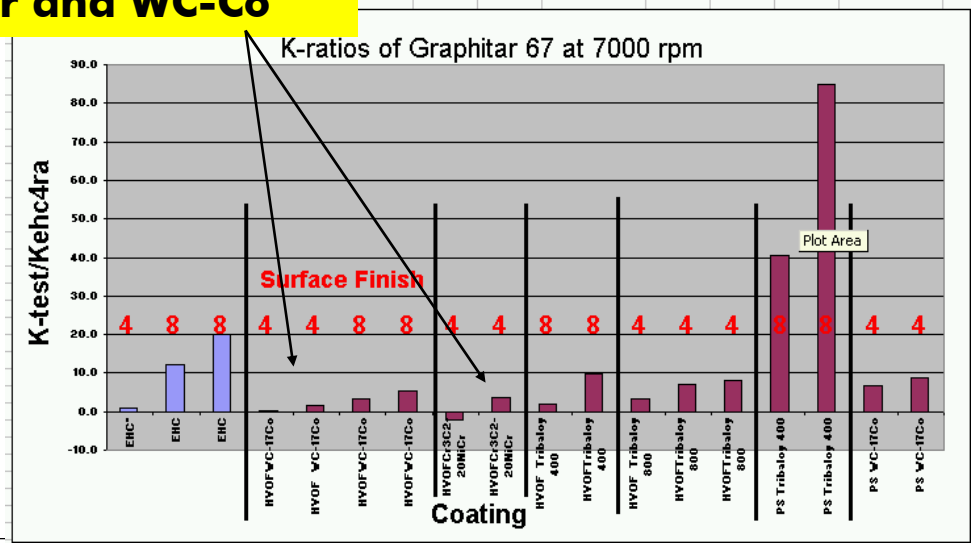
Wear of coating vs Graphitar 67 at 7,000 rpm



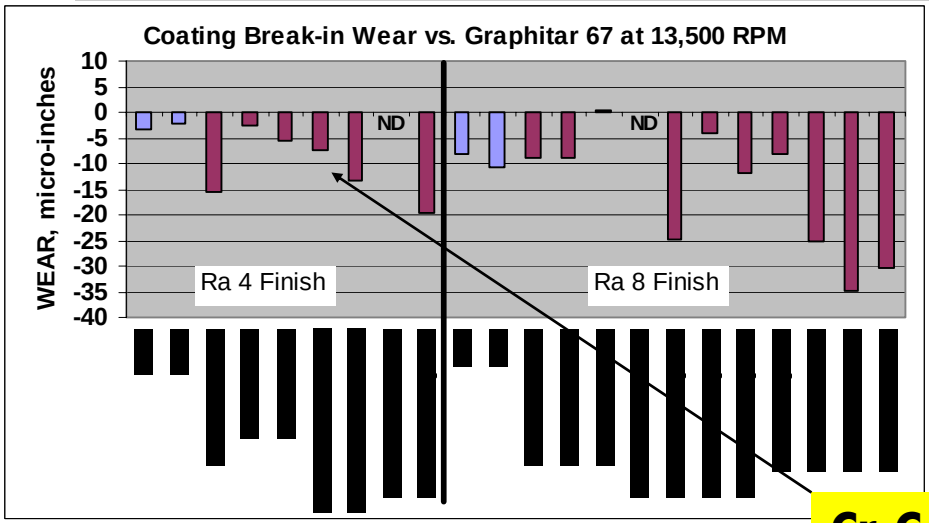


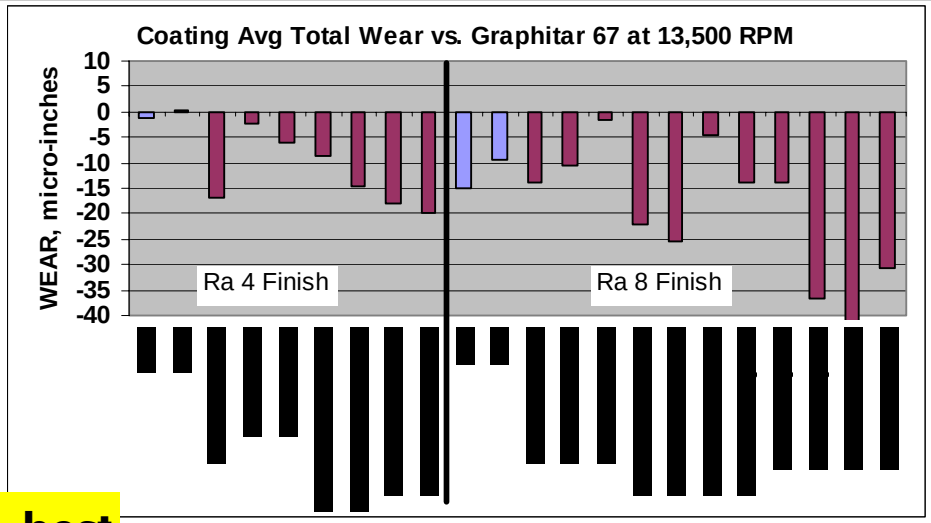
HVOF Cr_3C_2-NiCr and WC-Co best



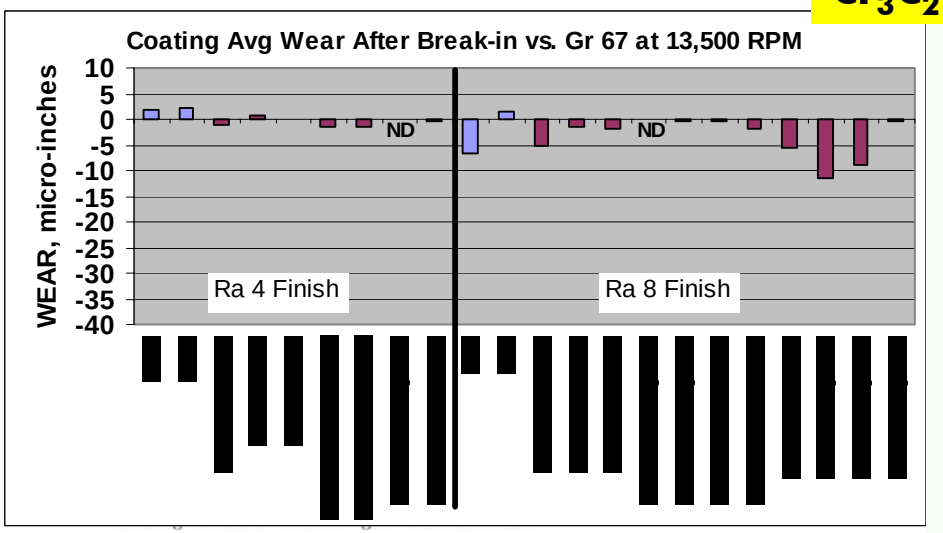


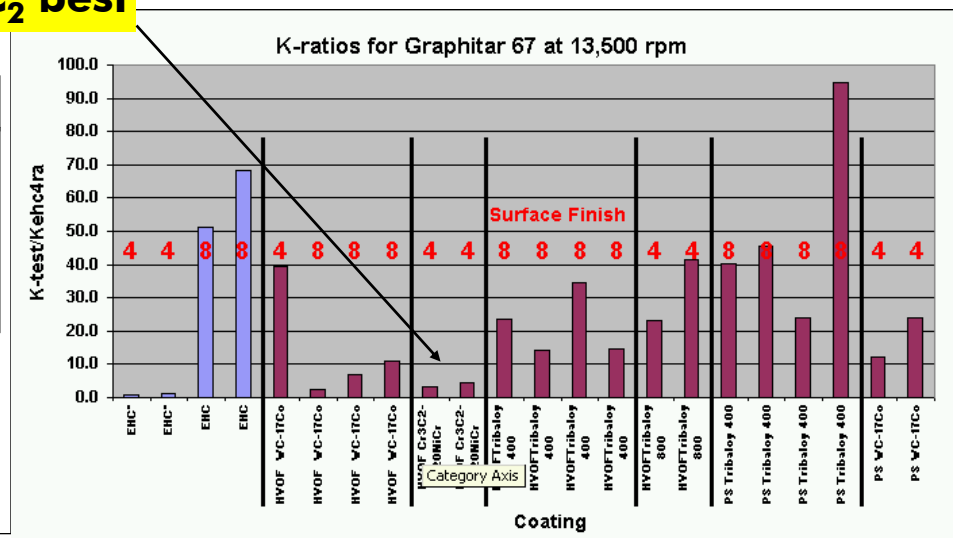
Wear of coating vs Graphitar 67 at 13,500 rpm





Cr_3C_2 best





ANOVA

- **Analysis of Variance shows that Load is by far the biggest factor**
  - **But also least controlled as spring-loaded, just as in GTEs**
  - **So some of what looks like differences between materials may be just differences between spring loads**

Source	Model DF	Reduced DF	Seq SS	Effect
Load	43	43	1093174	0.8174
Ctg	6	5+	214483	0.1604
Cg	1	0+	0	0
RPM	1	1	118	0.0001
Ra	1	0+	0	0
Setup	17	0+	0	0
Holder	3	0+	0	0
Housing	3	0+	0	0
Oil Jet	1	1	29573	0.0221

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Conclusions

- For Graphitar 39, HVOF WC-17Co looks best
- For Graphitar 67, HVOF Cr_3C_2-NiCr looks best
  - HVOF WC-Co does well at low speed, but causes high coating and seal wear at high speed

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