TRIBOLOGICAL TUFT TESTING OF CANDIDATE BRUSH SEAL MATERIALS

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Research Goals

- Develop test method to tribologically brush seal materials
- Evaluate materials to identify potential improvements and trends
- Guide seal material development and selection

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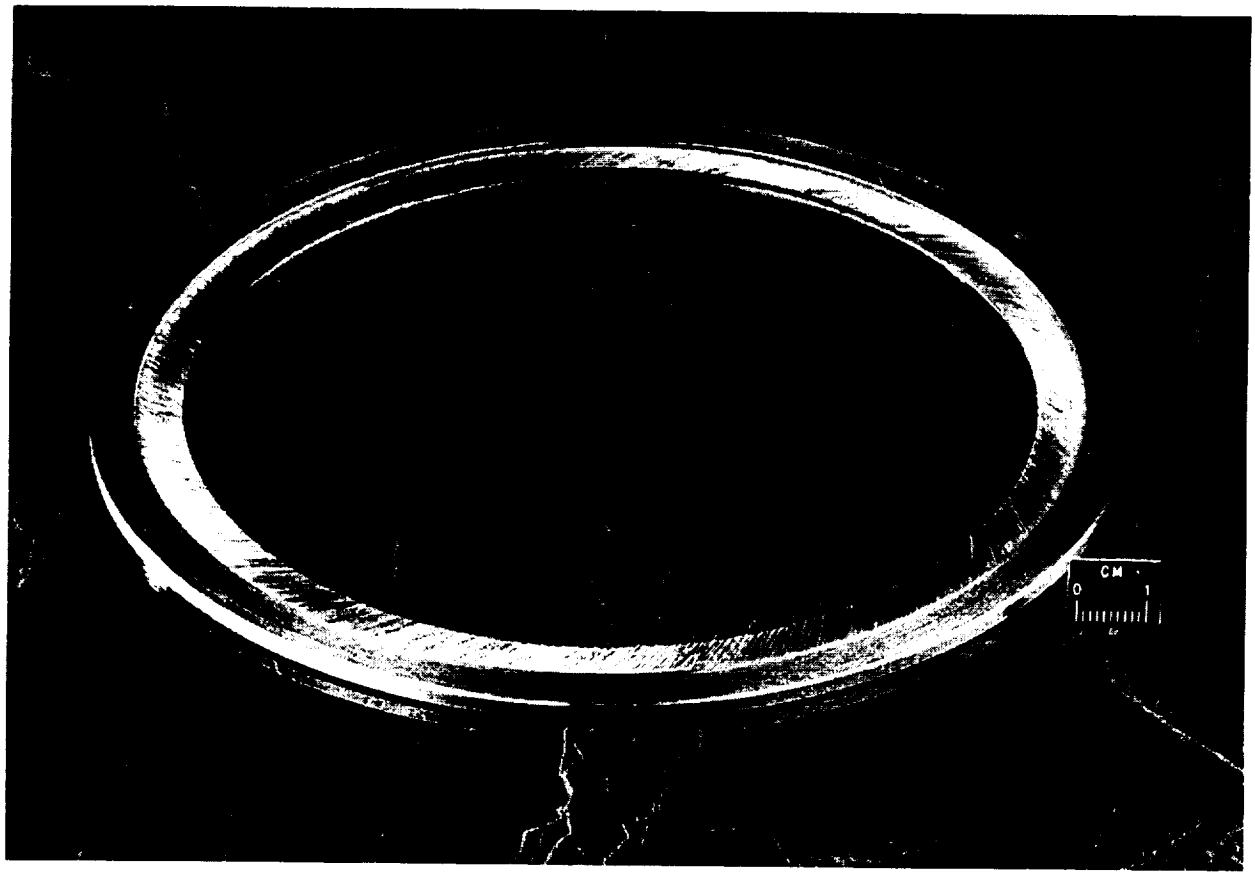
Turbine Engine Brush Seal



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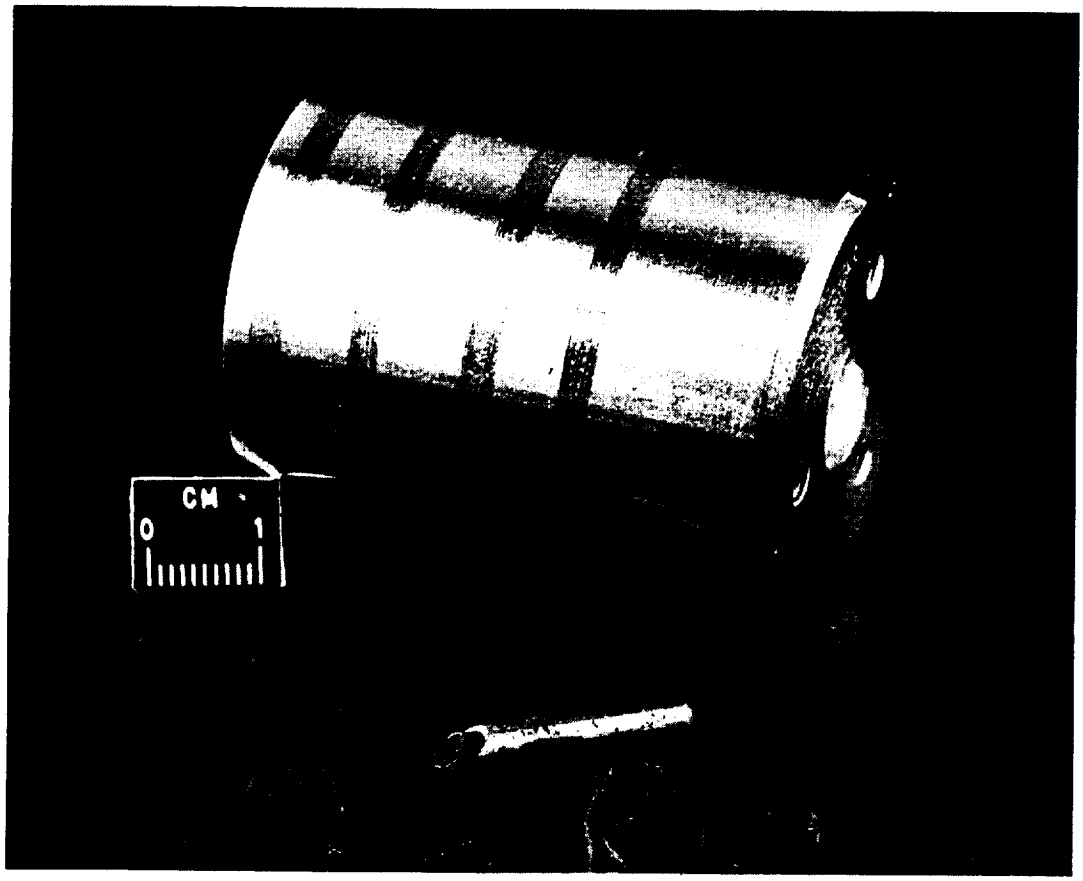
Photograph of typical brush seal

Brush Seal Simulation Specimens



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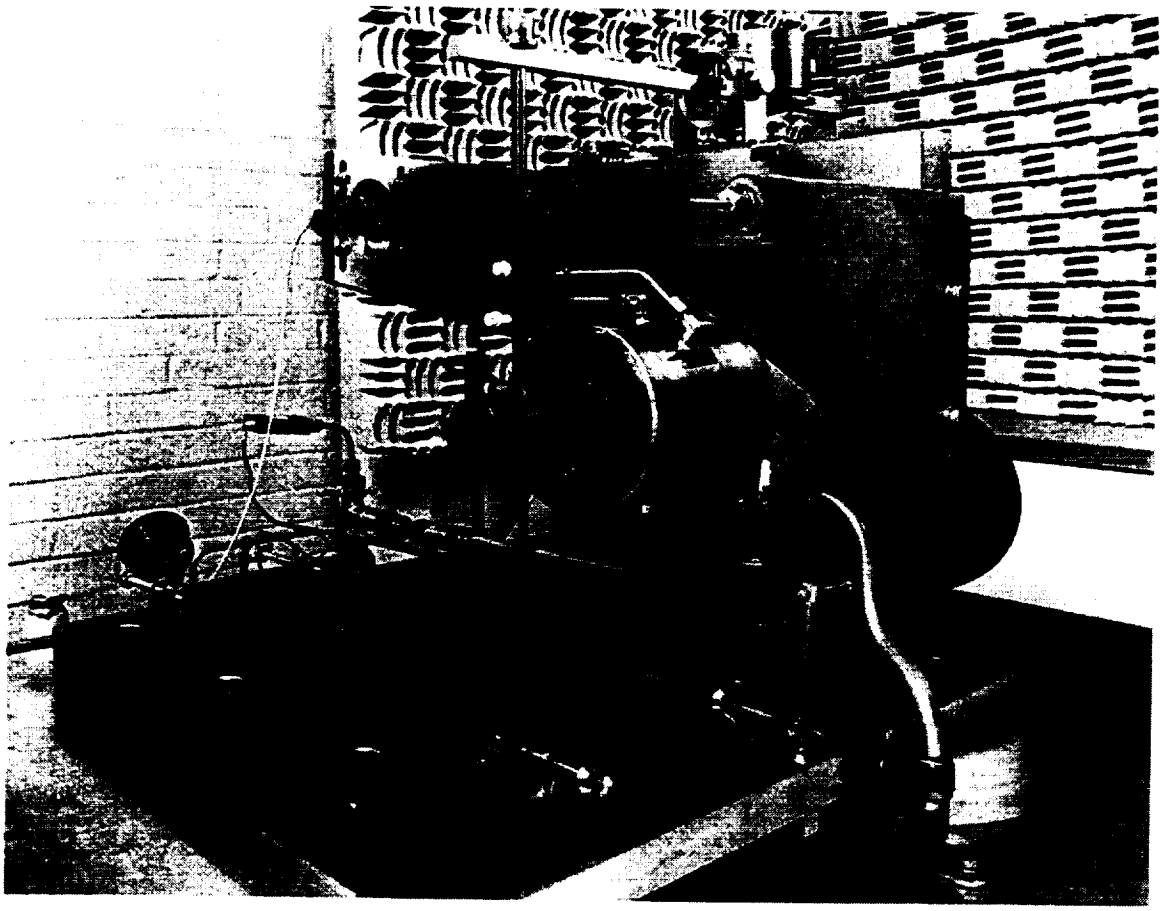
Tuft (lower) and journal (upper) specimens used to simulate brush seal/shaft sliding contact. Note that tuft wears groove into shaft surface.

Brush Seal Tuft Test Rig



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Photograph of high temperature (1400°F) tuft test rig showing specimen arrangement for testing.

Comparison of Simulation to Seal

Characteristic	Brush Seal	Tuft Test
Loads	0-20 psi (variable)	1-20 psi (constant)
Speeds	≈ 1000 ft/sec	≈ 100 ft/sec
Temperatures	75 - 1200°F +	75 - 1400°F +
Tribological	?	Friction Forces Wear Data

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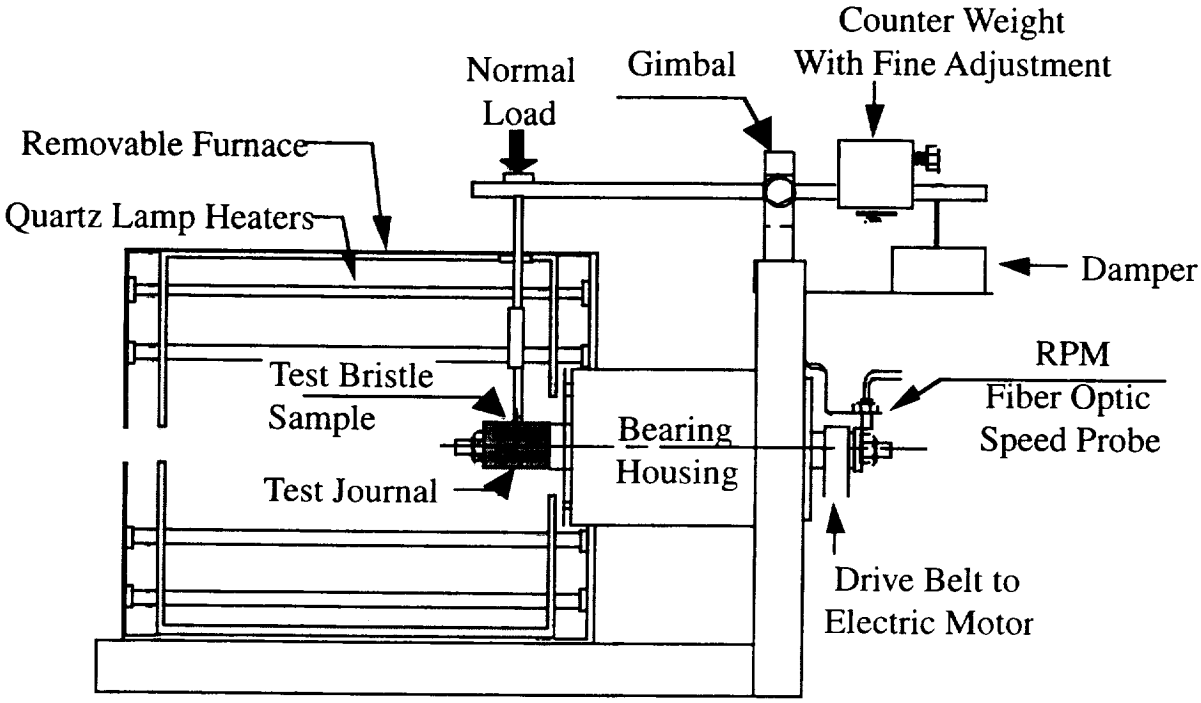
The tuft test can simulate most of the sliding conditions encountered by brush seals. In addition, friction and wear can be easily measured.

Schematic of Tuft Test Rig



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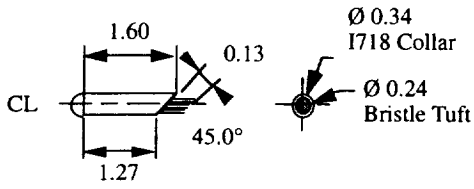
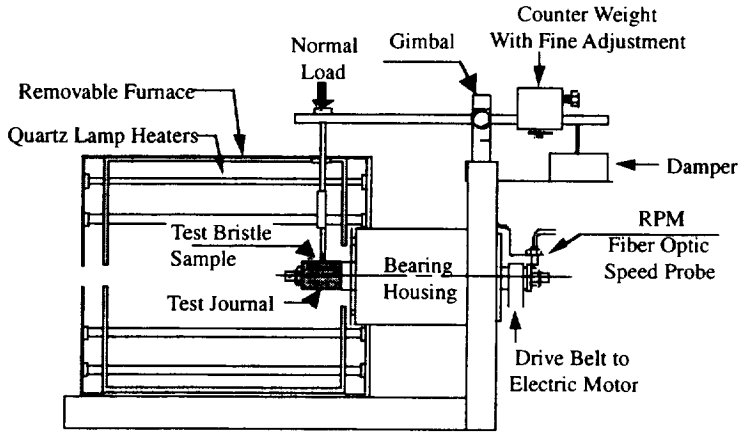
Test Specimens

Tuft



Journal



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Tuft sample is made by packing 960 wires into an Inconel collar. The wires are held in place by welding followed by grinding of the tuft surface to a 45° angle.

Brush Specimen Configuration

Chemical Composition of Wire Samples (wt.%)

	Co	Ni	Cr	Fe	W	Mo	OTHERS (< 6 wt.%)
H25	51	10	20	3	15	—	Mn, Si, C
I718	—	52.5	19	18.5	—	3	Nb, Ti, Al, C, Cu
H230	5	52.7	22	3	14	2	Si, Mn, C, Al, B, La
H242	2.5	60	8	2	—	25	Mn, Cu, Al, Si, C, B

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Operational Issues

- Vibrations
  - Interfere with accurate data collection and results in variable load

- Solution (s)
  - Add dashpot damper
  - Eliminate run-out using in place grinding system

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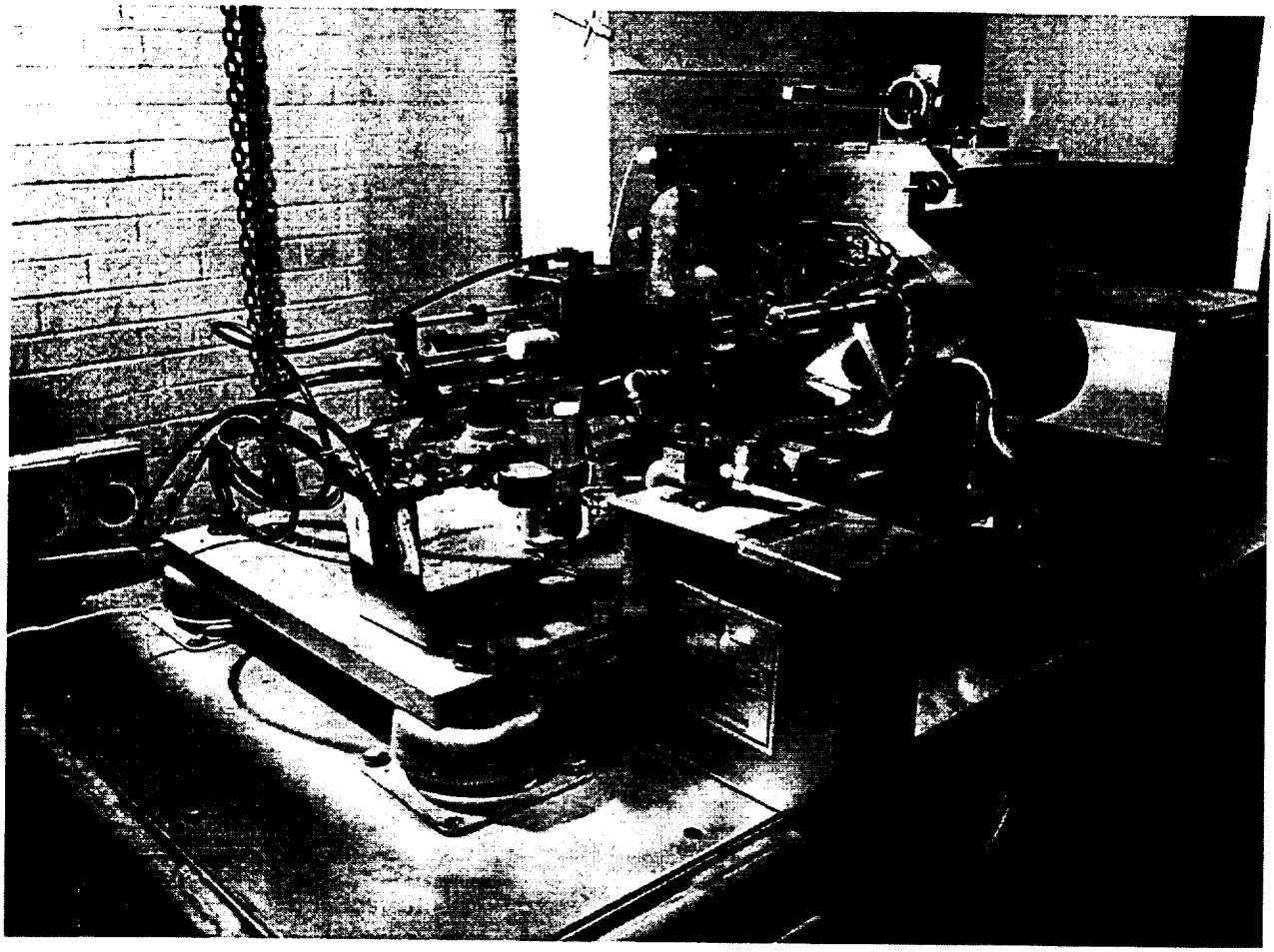
In-place Grinding System



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With this set-up, as coated journal specimens are mounted to the test rig shaft. In-place grinding, shown here, eliminates run-out and ensures a vibration free test.

Results Review

Testing of Solid Lubricant Coatings

Coating Compositions by Weight and Percent Volume of PS212, PS300, HVOF300

Coating	Constituent, wt.% (vol. %)			
Designation	Ni-Co-Cr_2C_3*	NiCr-Cr_2O_3**	Ag	BaF_2/CaF_2
PS212	70 (67)	—	15 (9)	15 (24)
PS300 and HVOF300	—	80 (80)	10 (6)	10 (14)

* By wt.% contains 54 Cr_2C_3, 28 Ni, 12 Co, 2 Mo, 2 Al, 1 B, and 1 Si

**By wt.% contains 80 Cr_2O_3, 16 Ni, and 4 Cr

refs. 4, 5, and 6

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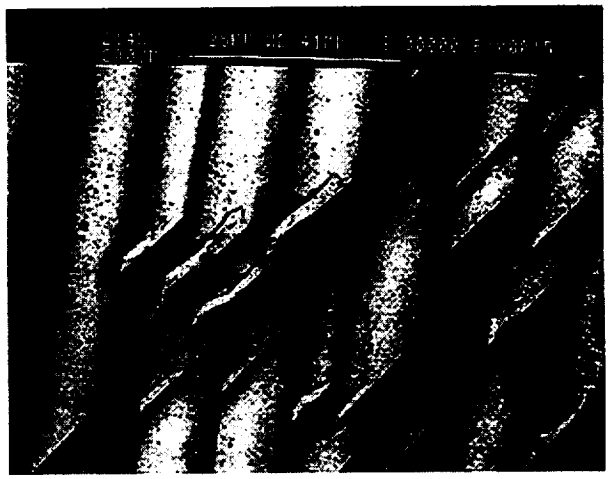
Typical Surface Appearance

Tuft Test

Brush Seal



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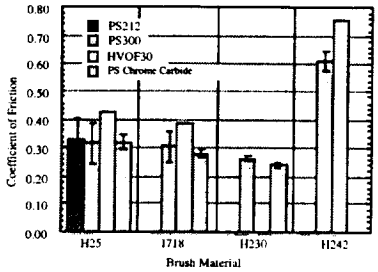
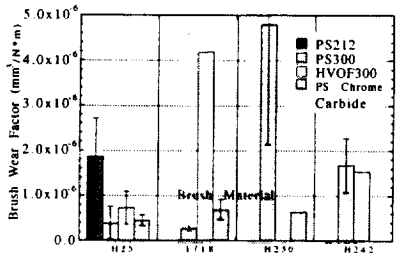
Note that the surface features observed after tuft testing match those seen in brush seals. This lends confidence in the relevance of the tuft results.

Tribological Data (1200°F)

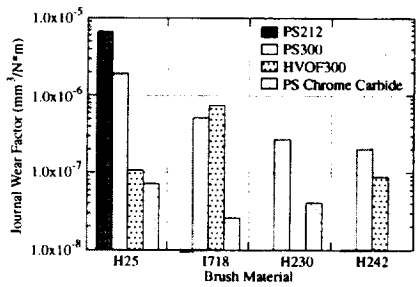
Friction



Brush Wear



Journal Wear



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Friction and wear data summary shows that the choice of wire material has a significant effect on friction. Journal coating can have a dramatic effect on both brush and journal wear.

Data Summary

- Friction largely unaffected by coatings
- Wear of "standard" materials better than "lubricated" coatings
- Data may be influenced by coating microstructure

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Summary

- Tuft test excellent screening tool
- Wear data suggests an improvement in 2 + orders of magnitude desired for long life of interference fit
- Tester capable of 1400°F + making it ideal for selection of alternate wire materials (e.g. ceramics)

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Relevant Publications

"Preliminary Tuft Testing of Metallic Bristles Versus PS212, PS300, and HVOF300"
NASA TM 107522

"High Temperature Brush Seal Tuft Testing of Selected Nickel-Chrome and Colbalt Superalloys"
NASA TM 107497

"A New Tribological Test for Candidate Brush Seal Materials Evaluation"
NASA TM 106753

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