Rapid Vacuum Plasma Spray (VPS) Closeout of Liquid Rocket Engine Combustion Chamber Cooling Channels for Both Time and Cost Savings

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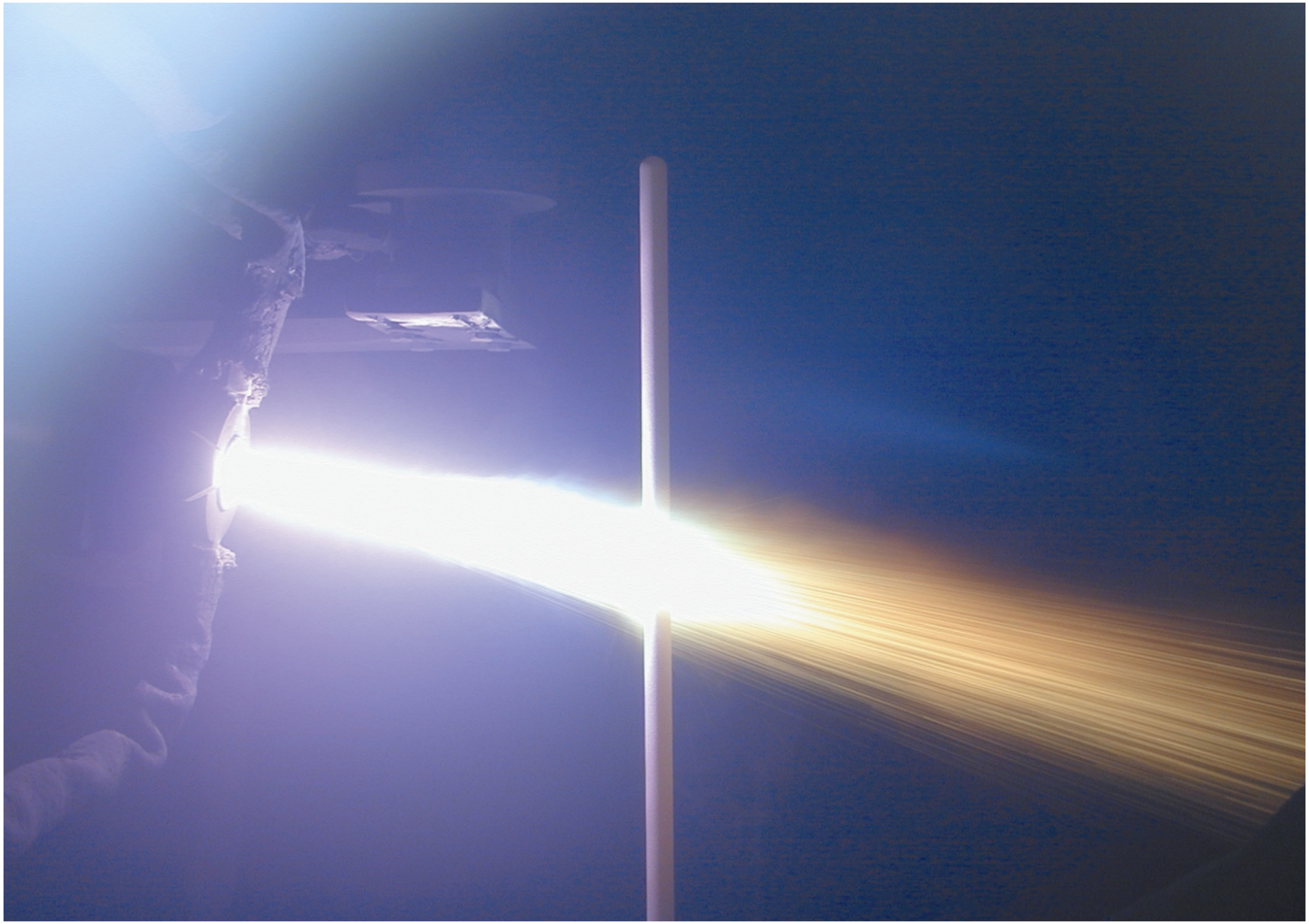
VPS Forming MoRe Cartridge to Safely Contain Tungsten Alloy at 1600°C



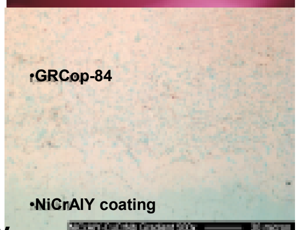
•VPS GRCop-84 Liner Development

•**MSFC CDDF Task**

•Developed FGM
•with VPS process
•for Space
•Furnace Cartridges
•+

•**GRC Task**

•Developed Superior
•Copper Alloy,
•GRCop-84

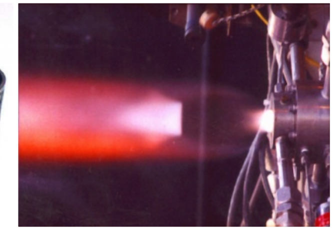


•(VPS = vacuum plasma spray
•FGM = functional gradient material)

•FY97

•**MSFC CDDF Task**

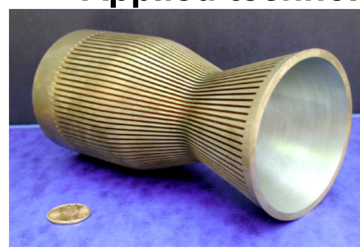
•Combined VPS, FGM, & GRCop-84 on small chamber liners

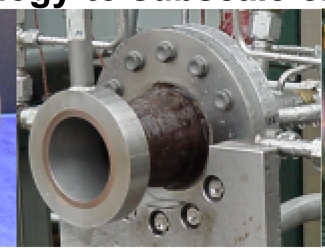


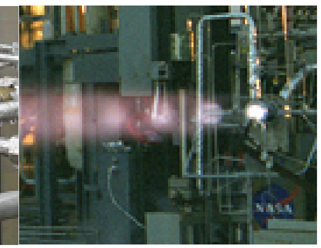
•FY98-99

•**MSFC CDDF + NRA8-21 Tasks**

•Applied technology to subscale chamber liners







•FY99-
•FY01

•**NRA8-21 Task**

•Fabricated midsize chamber liners for
•higher thrust levels

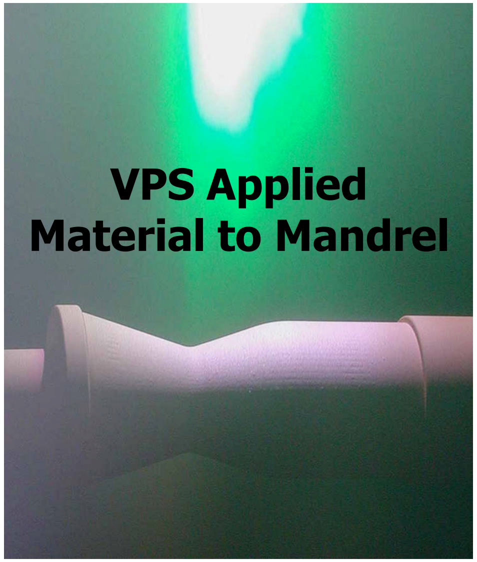
•FY01-
•FY03

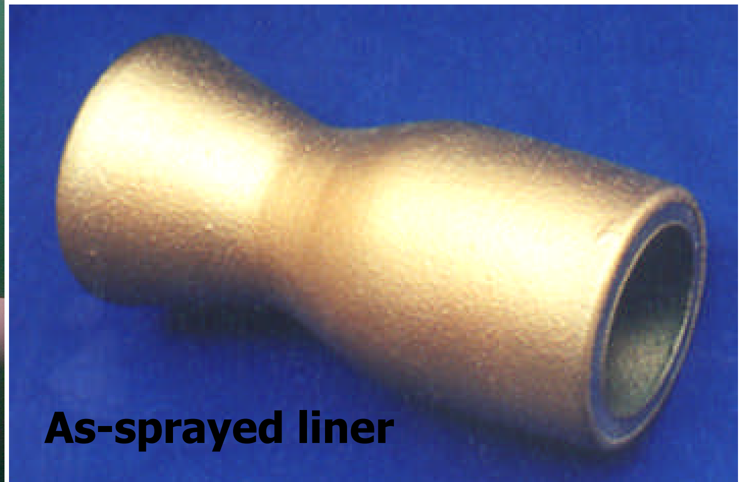
•**NGLT**

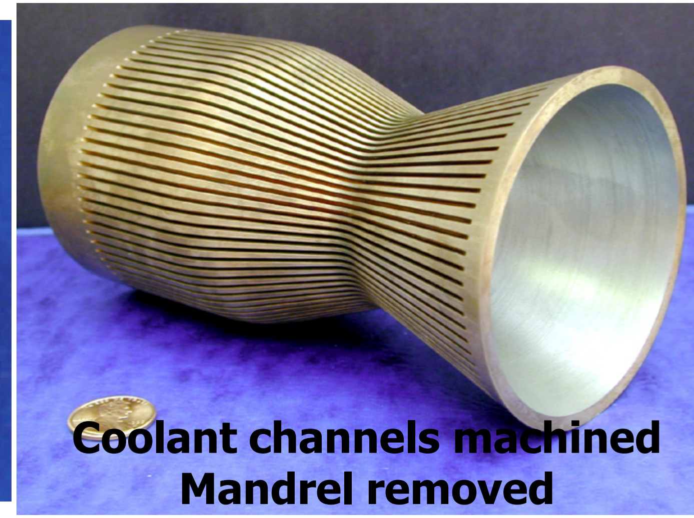
•Demonstrating
•technology for
•large,
•"engine class"
•liners
•(SSME
•MCC size)

•FY02-03

5K Hardware Fabrication


VPS Applied
Material to Mandrel


As-sprayed liner


Coolant channels machined
Mandrel removed


Channels filled


VPS Closeout Applied
& Machined

Manifolds Attached
PMC Jacket Applied (by Aerojet)

5K Hardware Testing

Plasma Processes, Inc.

220 Hot-fire Tests Performed to date

1100 seconds accumulated

P_c range: 750 – 1100 psig

Oxygen/hydrogen propellants

Liner Coolant: liquid hydrogen, water

GRCop-84 temperatures = 900 – 1250 F

Assembly Installed at MSFC - TS115

Hot-fire Testing at MSFC - TS115

<u>No</u> degradation observed for GRCop-84 liner or NiCrAlY hot wall layer

Alternate Material & Process

Functional Gradient Material (FGM)

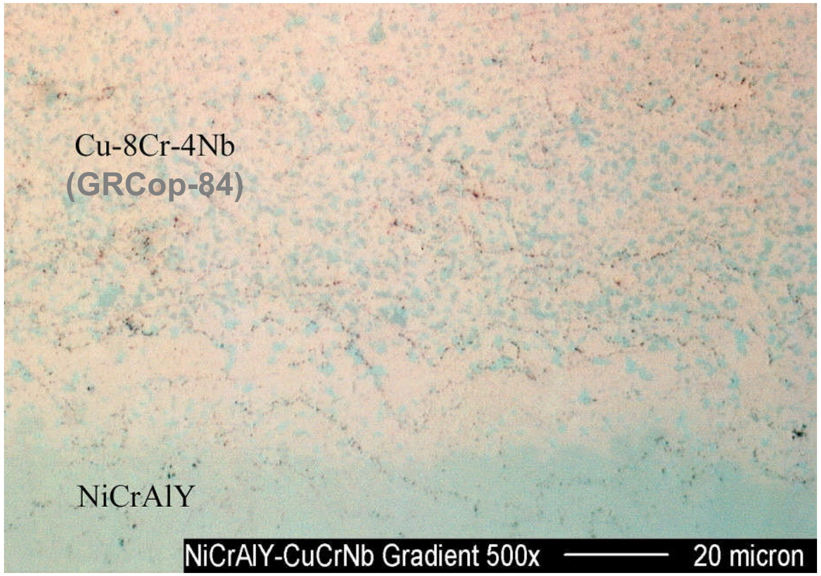
Hot wall layer: NiCrAlY

Gradated to ----

Liner Material: GRCop-84

Formed with ----

Vacuum Plasma Spray (VPS)



Advantages

- NiCrAlY layer offers maximum blanch protection
- No distinct bond joint between material layers
- Near net shape part
- Reduced fabrication schedule
- Higher operating temperatures
- Higher reliability, longer life

5K Hardware Performance

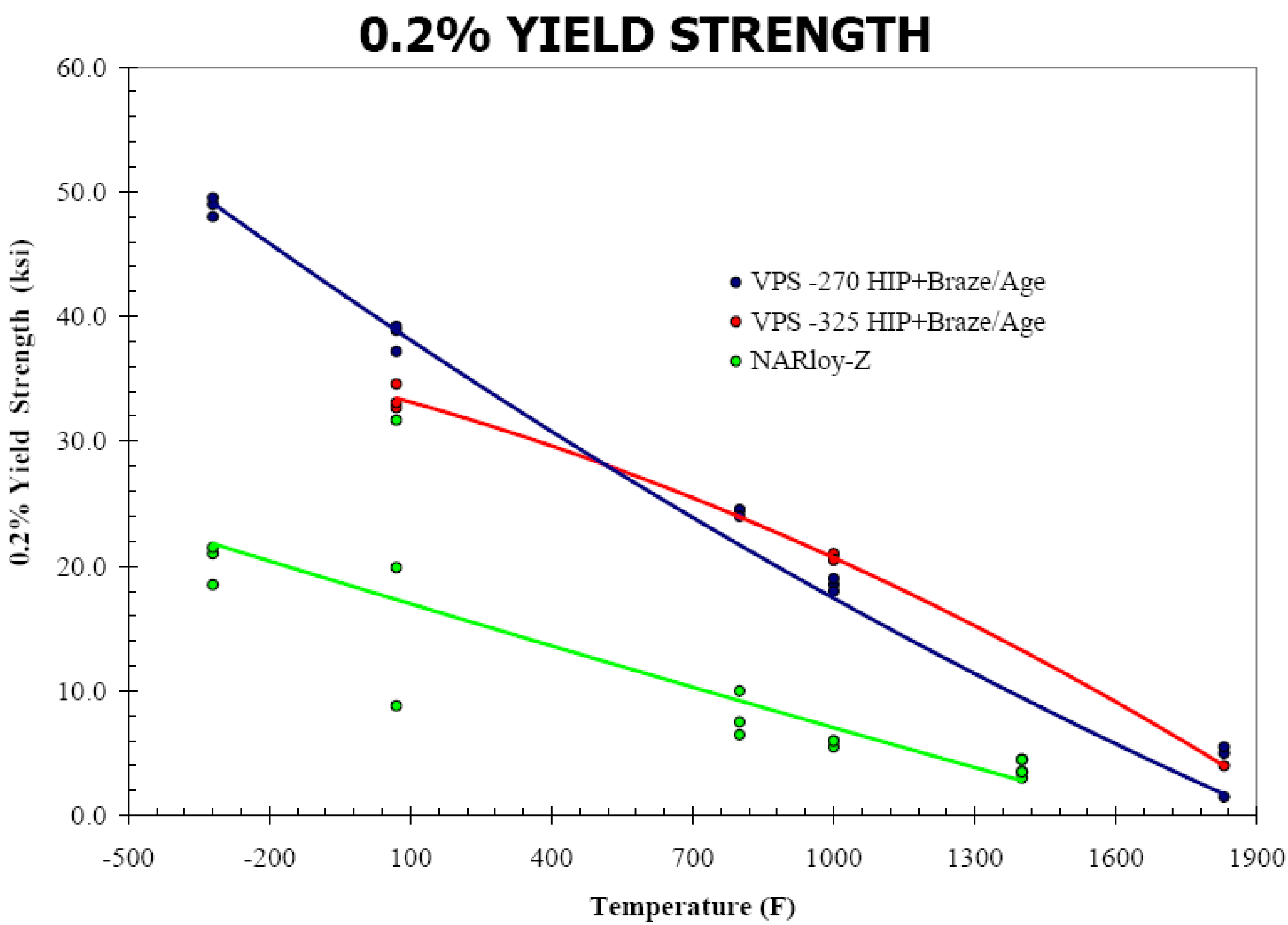
Subscale Cycle Test Comparison

VPS GRCop-84 Liner	NARloy-Z Liner
2003 - Technology Evaluation	1976 - SSME Qualification Testing
108 Cycles (520 sec, total)	118 Cycles (353 sec, total)
Max. GRCop-84 temp = 1250 F	Max. NARloy-Z temp = 1100 F
No hot wall cracks or surface roughening ever initiated – no liner degradation at all	Cycles < 30, Hot wall cracks & Surface roughening initiated
Cycle ~ 55, heat load decreased 30% less coolant required	Cycle ~ 70, heat load increased Surface polishing required

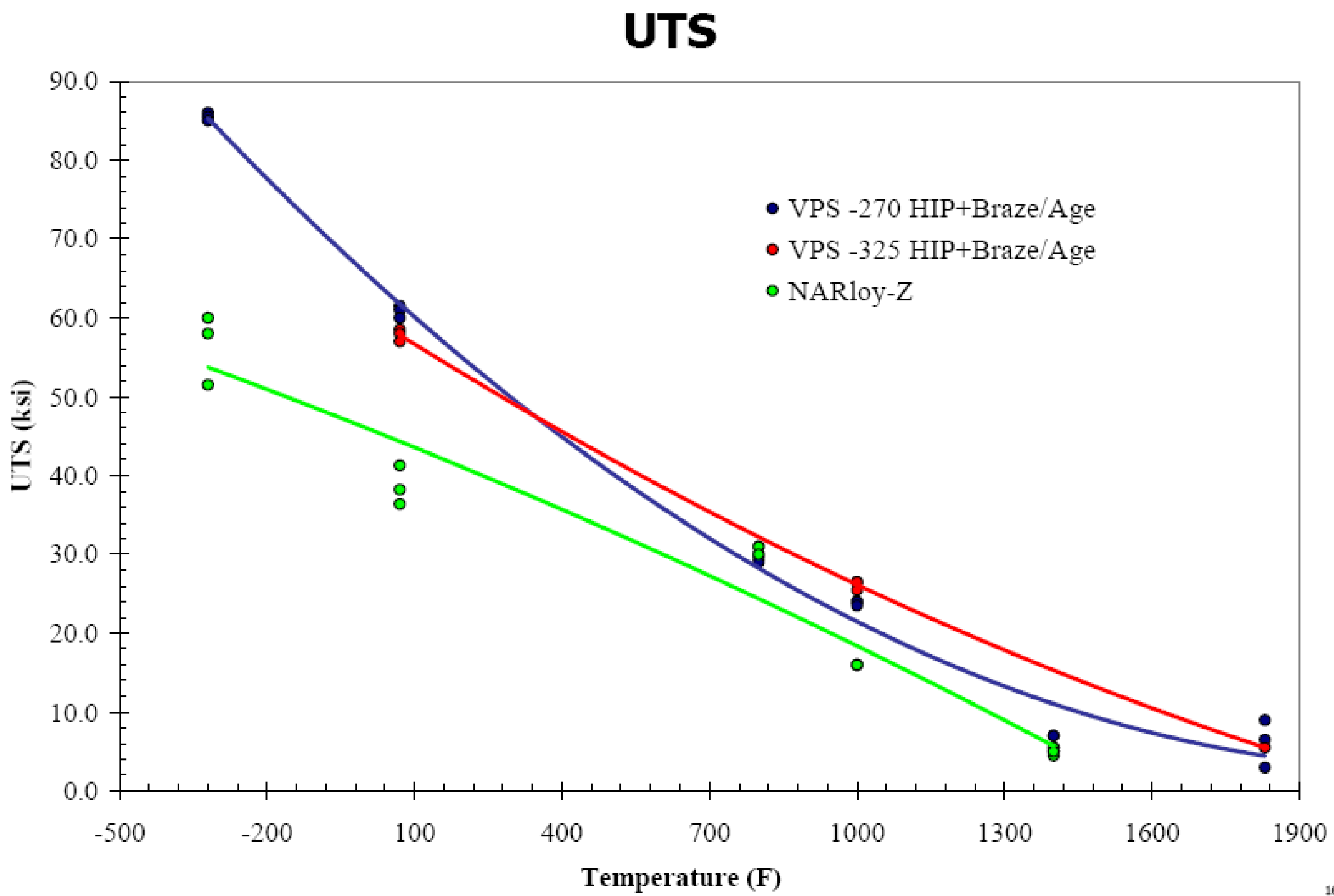
NARloy-Z avoids O_2/H_2 ratios of 8:1 due to blanching.

VPS GRCop-84 liner: 9 tests at 8:1 with no signs of blanching!

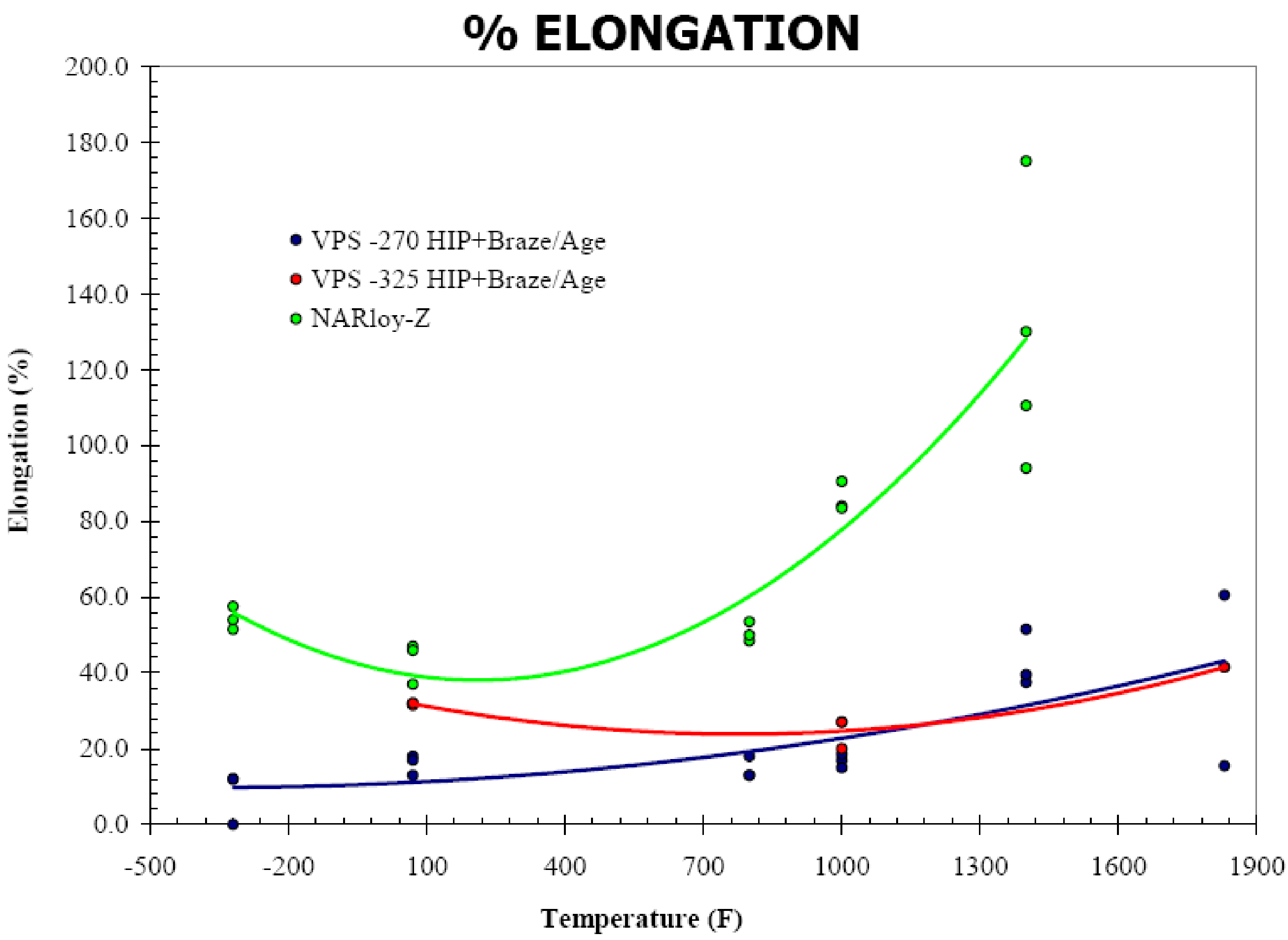
Material Testing Results



Material Testing Results



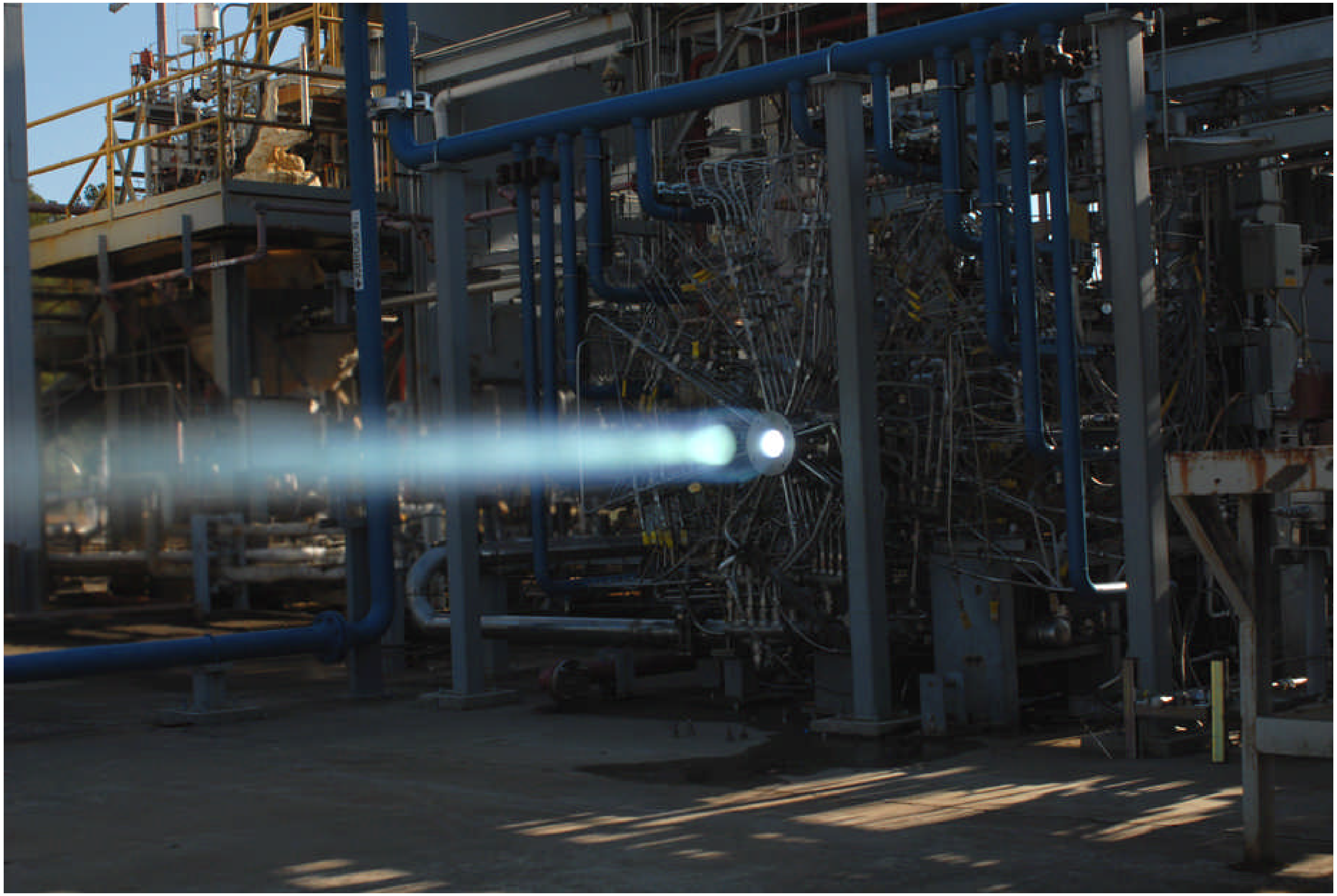
Material Testing Results



40K Thruster with Cooling Channels Cut Circumferentionally

40K Thruster to being Tested as a Calorimeter

Hot Fire Testing 40K Thruster as Calorimeter



Summary

- Demonstrated high performance of VPS FGM with hot-fire cycle testing
- Demonstrated Rapid Closeout of Combustion Chamber Cooling Channels for Reduced Time and Reduced Costs
- Increased VPS material database
- Currently testing 40K thruster as a Calorimeter

Further Information

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