



Material Loss Rate for Tungsten Irradiated with 800 MeV Protons

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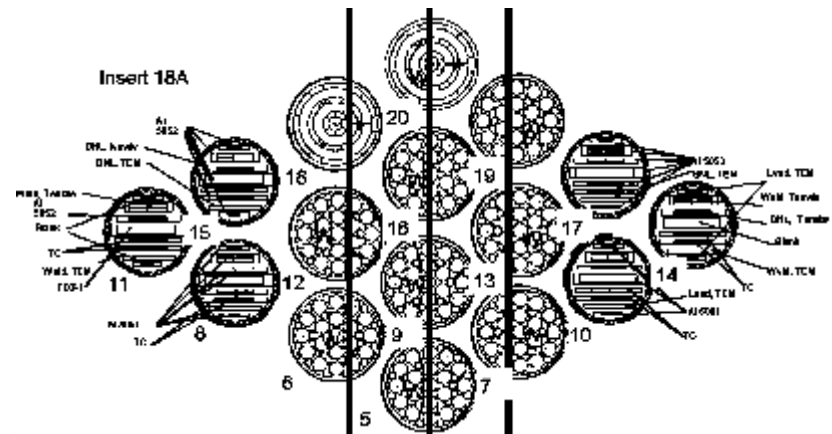
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Irradiation of Pure Tungsten in Proton Beam Revealed high Corrosion Rate



Bare Tungsten Neutron Source Capsule

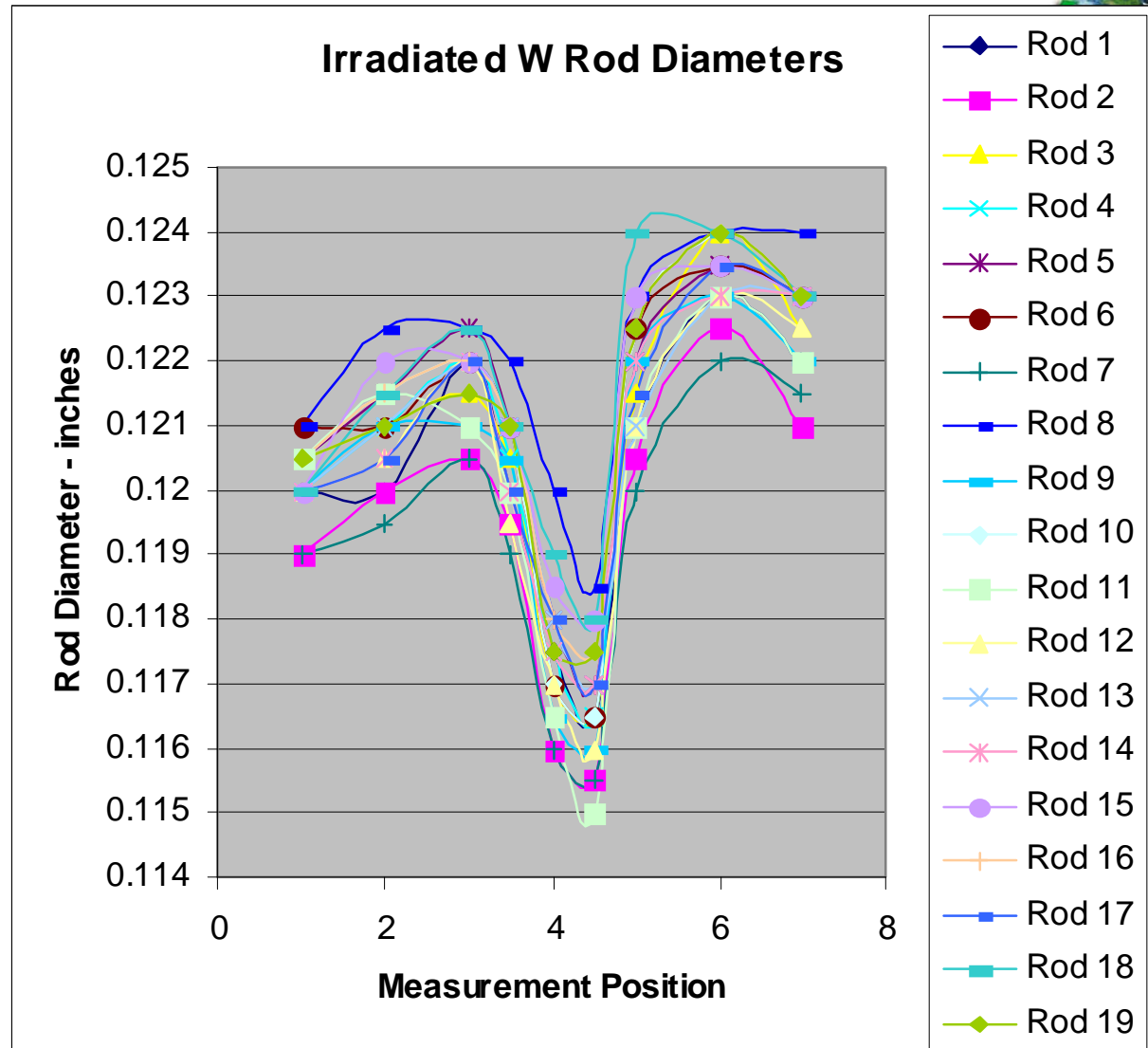


- 1/8 in. diameter rods
- 19 rods per bundle
- Cooled with flowing water
- Water inlet Temperature ~30C, Delta T~10C
- Max. W surface T~166C
- System pressure = 13bar
- Coolant velocity ~ 2.9 m/s
- Water pH during operation ~ 4.5

Decrease in Diameter of Bare Tungsten Rods Confirmed Tungsten Corrosion Rate



- Capsule irradiated for 2 months in 800 MeV, 1 mA proton beam (1.32×10^{21} p/cm²)
- Measured the diameter of all 19 tungsten rods in the leading rod bundle.
- The loss of tungsten on rods scaled with Gaussian beam shape.
- Measured Helium concentration of ~740 appm



Corrosion Rates Measured on Samples from Corrosion Insert

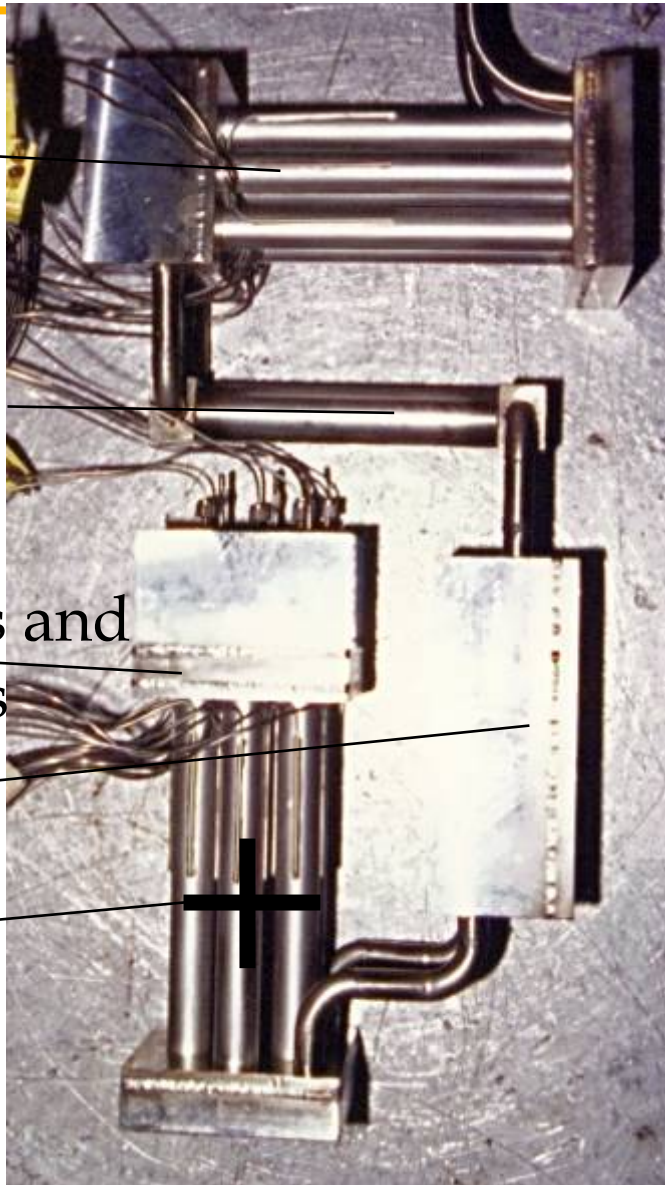


Out-of-Beam
Weight Loss
Specimens

W/Ti and W/Re
Samples

Corrosion Probes and
In Beam Wt. Loss
SCC Specimens

Beam Center



Installed During Accelerator Break
(11/96-2/97)

Contained In-beam corrosion probe of
Inconel 718

Cooled with separate controlled water
system

- Bubbled Hydrogen during irradiation
- Used High resistivity water
- pH=4.5

Contained weight loss samples in proton
beam and out-of-beam.

Contained U-bend Stress corrosion
Cracking specimens

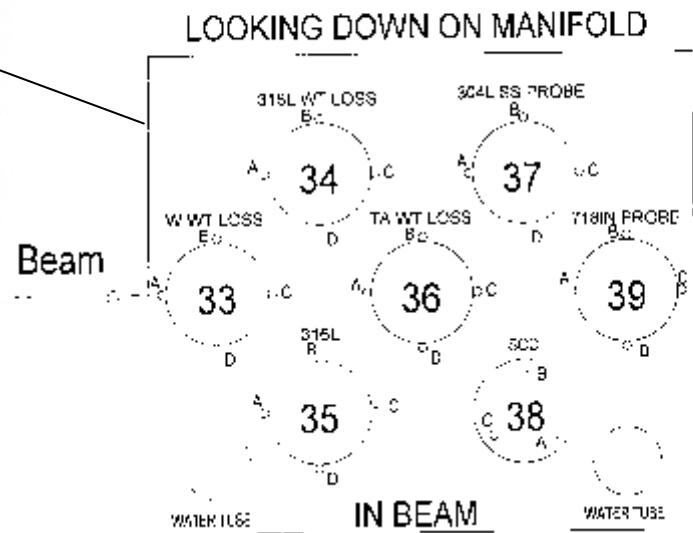
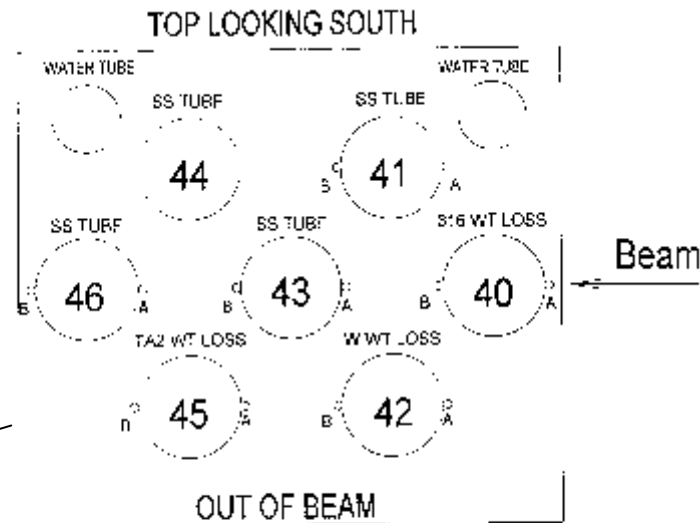
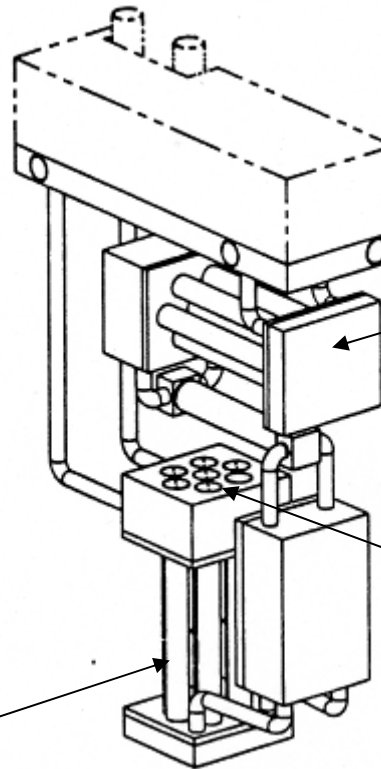
Corrosion probes placed above insert to
measure corrosion rate in irradiated
water.

Set-up of Corrosion Insert



- Coupons irradiated in '97 APT irradiation for ~4 months
- Separate water system used for cooling samples

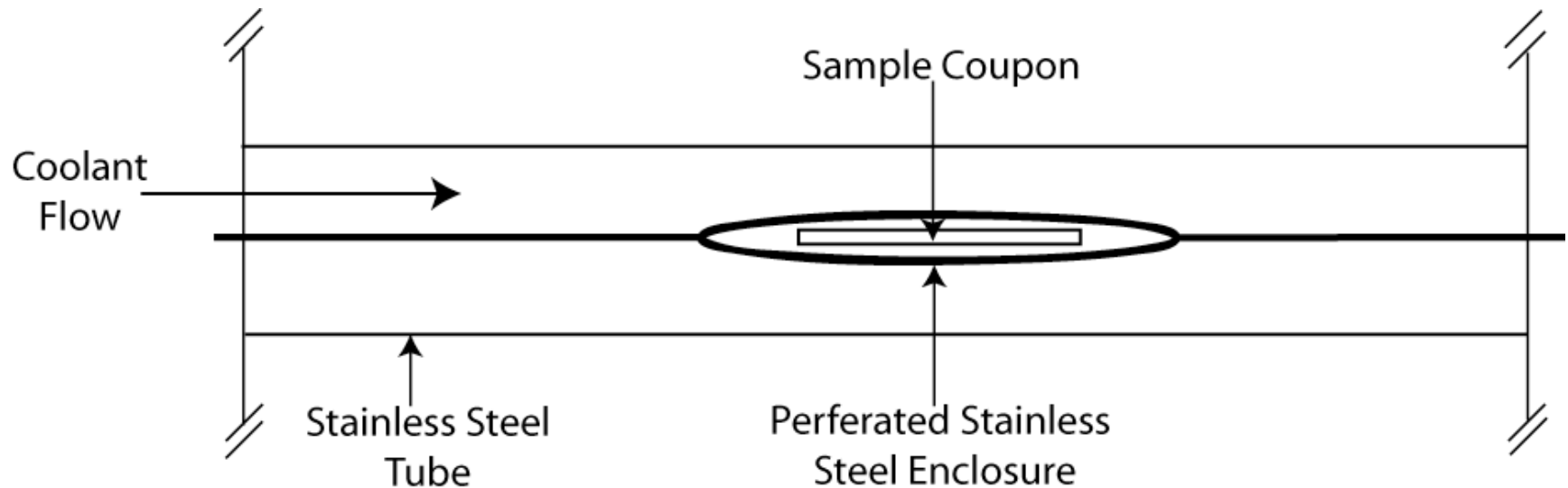
Incident Beam,
800 MeV, 1 mA
p+ beam
Calculated energy
at this insert is
~400 MeV



Corrosion Coupon Set-up



- Corrosion Measurements made on tantalum, tungsten and 316L corrosion coupons after irradiation in the LANSCE beam



Corrosion Rates Measured for W, Ta and 316L



- Dose calculated ranged from 0.02 to 2.0 dpa
- Corrosion was only observed for the W samples
- Calculated flow rate was 1.0 m/s

Probe number	Material	Location	Neutron Fluence	Proton fluence	Total dpa
34	SS316	In-beam	1.74E+20	2.14E+20	0.6229
33	W	In-beam	2.03E+20	2.85E+20	2.0177
36	Ta	In-beam	2.30E+20	2.76E+20	1.8373
40	SS316	Out-of-beam	8.56E+19	1.31E+18	0.02796
42	W	Out-of-beam	7.98E+19	1.02E+18	0.03334
45	Ta	Out-of-beam	7.78E+19	9.55E+17	0.02254

Sample tube #	Material type	Weight before irradiation (g)	Weight after irradiation (g)	Weight Change (g)	Average Corrosion Rate (μm/yr)
33	tungsten	5.175	4.8403	-0.335	65
34	316L SS	4.628	4.6276	-0.000	
36	tantalum	8.515	8.514	0.001	
40	316L SS	4.499	4.4992	0.000	
42	tungsten	5.202	5.0899	-0.112	22
45	tantalum	8.532	8.5329	0.000	

Cladding of LANSCE Tungsten Neutron Scattering Target with Tantalum

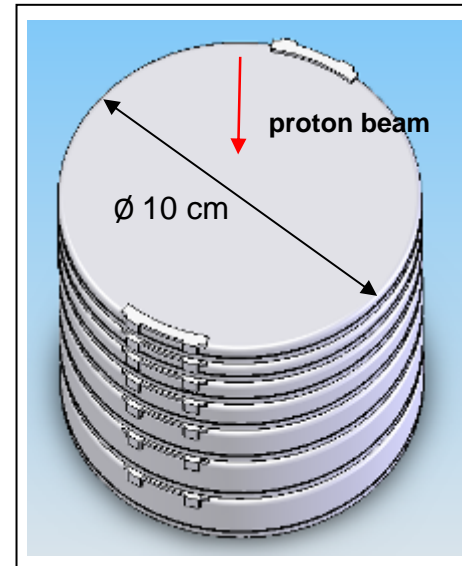
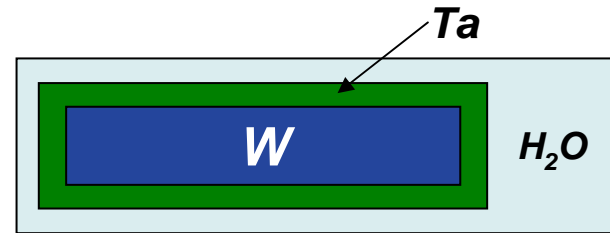


Plans underway to Clad MLNSC Target with Ta

- Main reason is to reduce activity for the water cooling system
- Initial HIP bonding tests at 1500C were successful
- Plan to have new targets fabricated by March 2009

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LANSCE

- Tungsten target 'pucks'
- Light water coolant
- Tantalum cladding



Summary/Conclusions



- Very high corrosion rates observed for tungsten under high energy proton irradiation
- Calculated tungsten removal rates of ~ 1.9 atoms/proton for ~ 760 MeV protons.
- Corrosion coupons of W, Ta and 316L analyzed after irradiation
 - No corrosion observed for Ta or 316L
 - High corrosion rates observed for W
- Ti-coated W and W-27Re analyzed after Irradiation
 - Ti coating peeled off during irradiation
 - Significant weight loss measured on W-27Re specimen
- Cladding undertaken to eliminate tungsten corrosion problems
 - Cladding W target with 304L reduced corrosion rates
 - Plans underway to HIP Clad LANSCE target with Ta