Water Erosion Experiment

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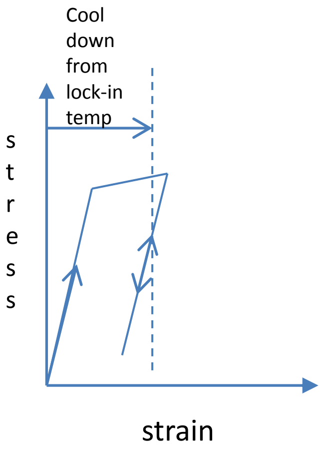
Motivation

- ISIS water cooled tungsten targets are clad with tantalum to avoid tungsten corrosion problems that occur when in direct contact with water
- ISIS TS2 target had to be replaced at the end of last year due to detection of tantalum and tungsten in the water circuit
- Stress state of the tantalum cladding during standard operation of TS2 is of interest

1. Potentially significant plastic deformation of the tantalum during the hipping process



2. Significant beam induced static stress as well as transient and inertial stress resulting from 25K temperature jump per pulse
3. Erosion rate of tantalum with TS2 water velocity is unknown

Tantalum erosion resistance is also of interest for
upgrades to TS1,
and for more general interest,
SNS target 2 and ESS backup solution

Mitigation of current TS2 target risks

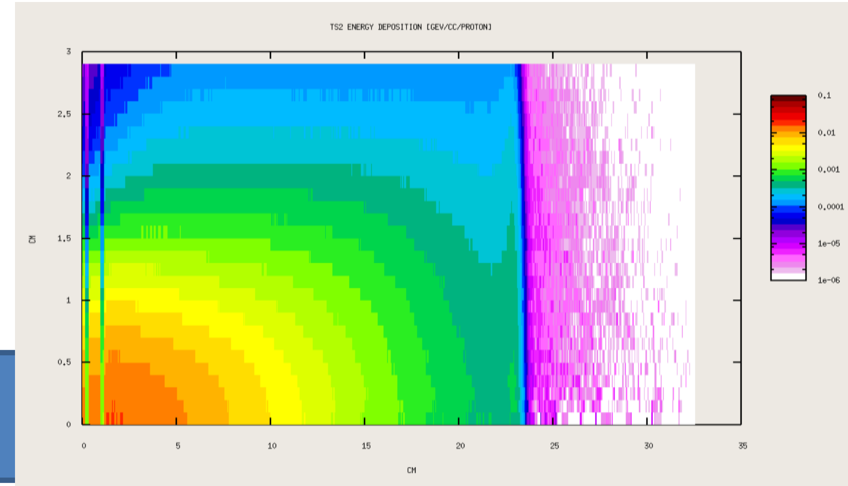
1. Investigate if beam size can be increased
2. Investigate erosion resistance of tantalum cladding and tantalum coatings to determine if water erosion is a problem (guidelines for water velocity in copper pipe are well known, very little information available on tantalum),

- if erosion not a problem consider alternative thinner low stress tantalum coating
- if erosion is a problem propose reduced water velocity design

Risk mitigation 1: Can beam size be increased?

BEAM SIGMA =6MM

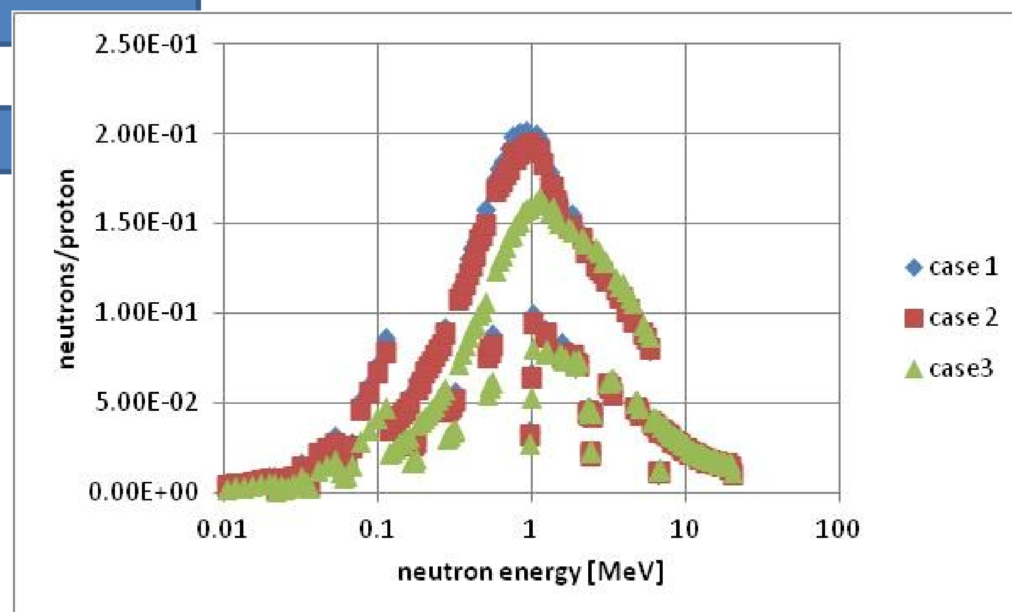
Target radius = 4.8Xsigma



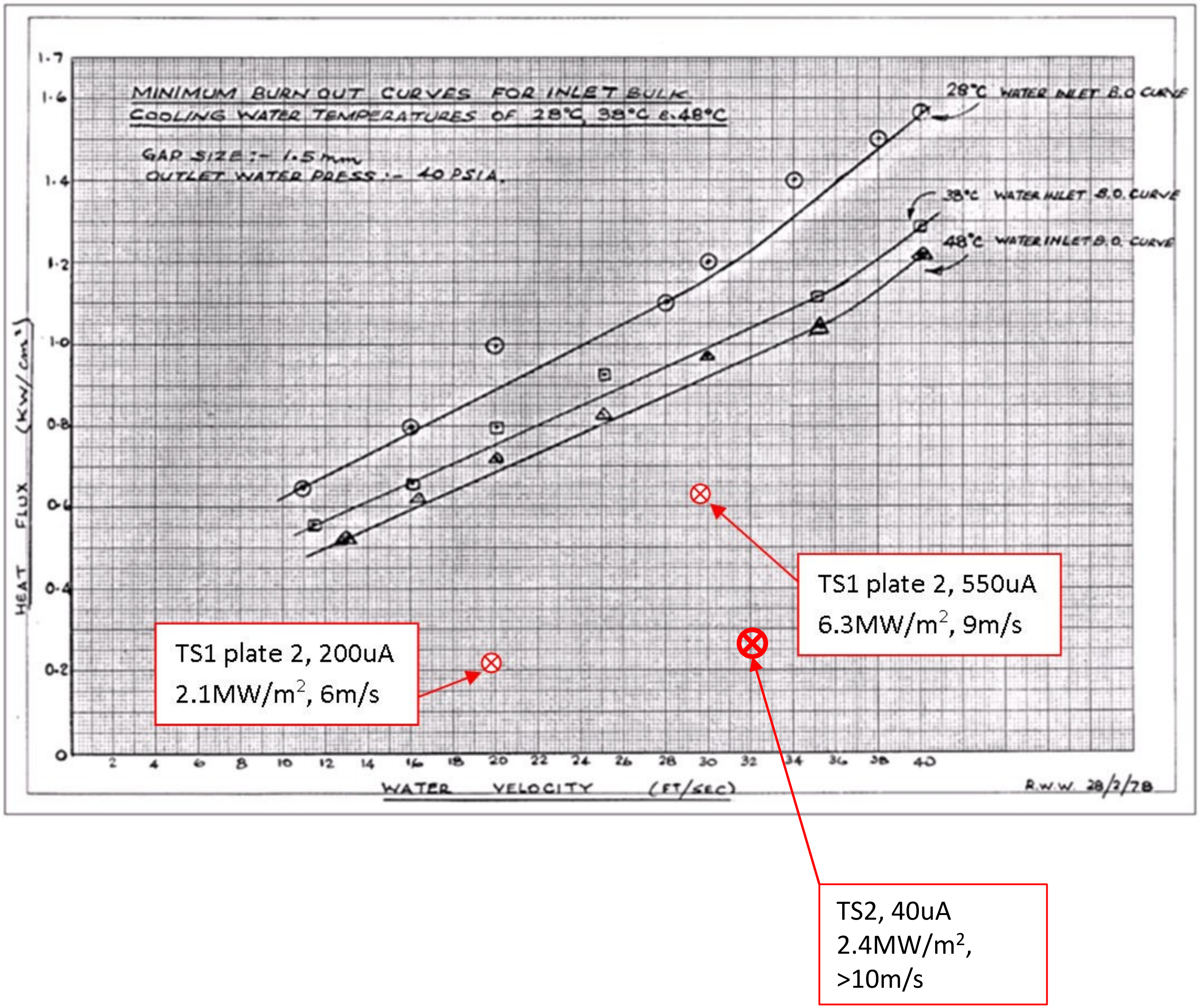
Case 1
beam sigma = 6mm
Target diameter = 58mm

Case 2
beam sigma = 9.7mm
Target diameter = 58mm

Case 3
beam sigma = 6mm
Target diameter = 36mm



Risk mitigation 2: Can water velocity be reduced?



Tantaline Chemical vapour deposition process
'potential low stress alternative to hipping'

Tantaline's Surface Alloy Technology Through the evolution of acid resistant tantalum coating technologies **Tantaline's Tantalum Suface Alloy Technology** has been developed. This technology has the capability of producing very repeatable and consistent pinhole free surface of pure tantalum metal at thicknesses between (50um - 200um). Tantaline is geometry independent because it utilizes a gas phase process. The Tantaline process occurs on an atomic level virtually eliminating the chance of creating voids and oxide inclusions which allows Tantaline to creating a 100% dense, ductile and stress free surface.

Tantaline is the highest performing most corrosion resistant material availabe. With higher corrosion resistance than **nickel alloys, Hastelloy C276, titanium**, **zirconium**, gold and **tantalum metal** at costs that beat them.

Thermal Stability of Tantaline - Thermal Cycling

Ten samples were cycled 100x by heating in an oven to 250C (482F) and then quenching in room temperature water. After 100 cycles the samples were analyzed and compared to the baseline sample. The tantalum surface as well as the 316 stainless steel substrate are in excellent condition and show no signs of defects or distortion that may typically be seen on traditional coatings that are thermal cycling. This result was consistent on all ten samples.

Bond Strength

Baseline adhesive samples range from 10000 - 12000psi. This is the force needed to fracture the adhesive.

Tantaline samples failed at 11,282psi and 12,307psi.

Tantaline usually applied to steel (SNS currently undertaking a study of bond strength when applied to tungsten)

No literature found on water erosion of tantalum or maximum allowable water velocity.

Proposed exchanging results with David McClintoch and Bernie Riemer at SNS

Comparison	Tantaline Alloy Bonding	Clad	PVD Coating	Cold Spray Coating	Thermal spray Coating
Minimum layer thickness for corrosion protection (mm)	0.01	1.00	0.50	0.50	0.50
Coating of narrow holes possible	YES	NO	NO	NO	NO
Alloy zone between base and surface	YES	NO	NO	NO	NO
Risk of delamination	LOW	HIGH	HIGH	HIGH	HIGH
Risk of under corrosion	LOW	HIGH	HIGH	HIGH	HIGH
Tension level in the surface	LOW	LOW	HIGH	HIGH	HIGH
Risk of cracks in deposited tantalum	LOW	HIGH / LOW	HIGH	HIGH	HIGH
Net shape parts can be handled	YES	NO	NO	NO	NO
Large Installation can be handled	NO	YES	NO	YES	YES
Performance / Price ratio	GOOD	POOR	POOR	POOR	POOR

Experiment

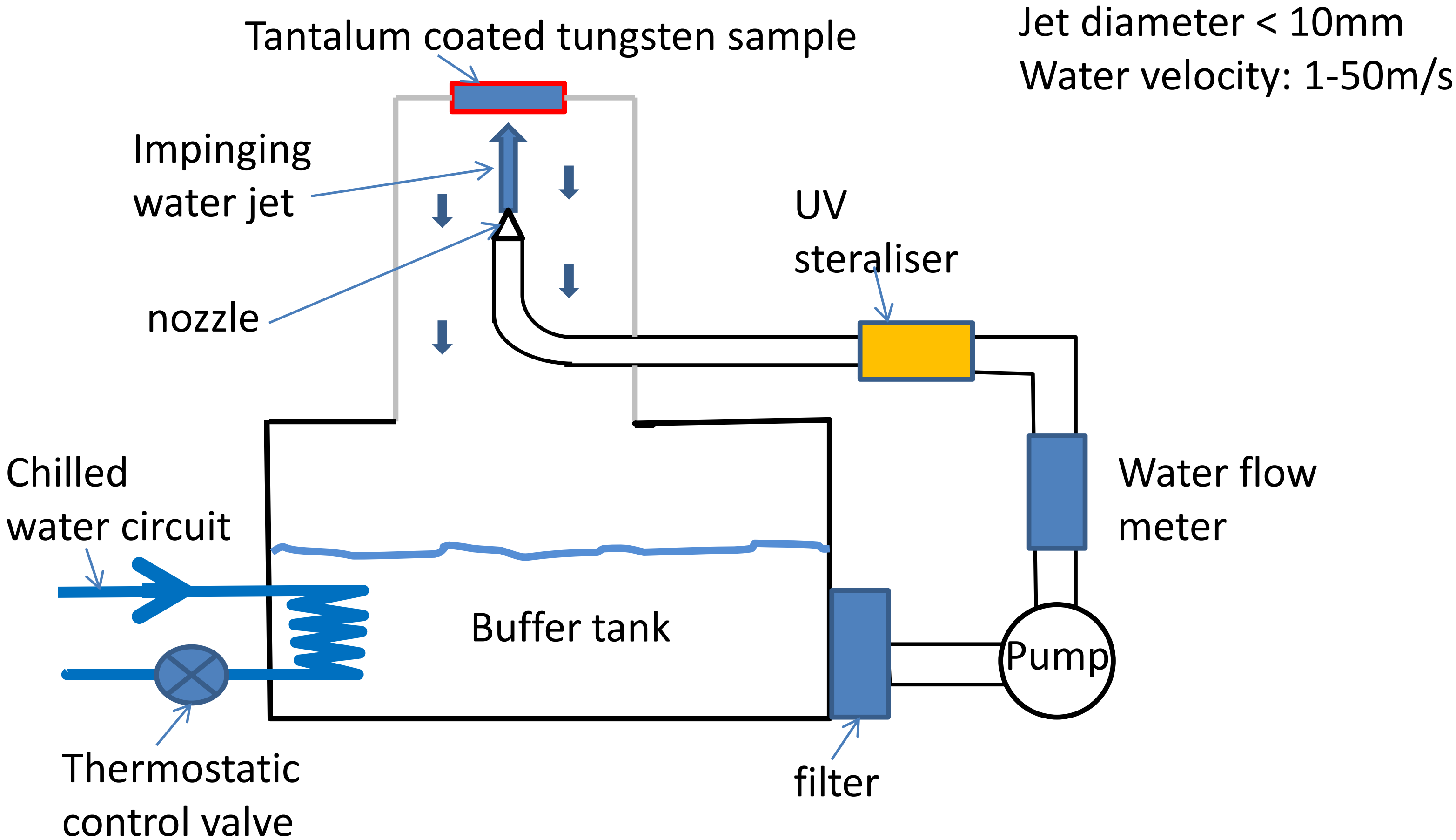
Aim – Investigate the resistance of tantalum cladding and tantalum coatings to erosion by high speed water cooling

Method – Use an impinging water jet to generate accelerated erosion rates

Outputs –

- Erosion rate vs water impingement velocity for tantalum.
- Erosion rate vs water temperature.
- Erosion rate following acid exposure (hydrogen embrittlement)
- Comparison of erosion resistance of tantalum cladding and tantalum coatings.

Apparatus



Tantalum coated tungsten sample
Jet diameter < 10mm
Water velocity: 1-50m/s
Impinging
water jet
nozzle
UV
steraliser
Chilled
water circuit
Water flow
meter
Buffer tank
Pump
Thermostatic
control valve
filter

Status

- Concept design almost complete (ideas welcomed)
- Major cost components ordered
- Detailed design starting in March