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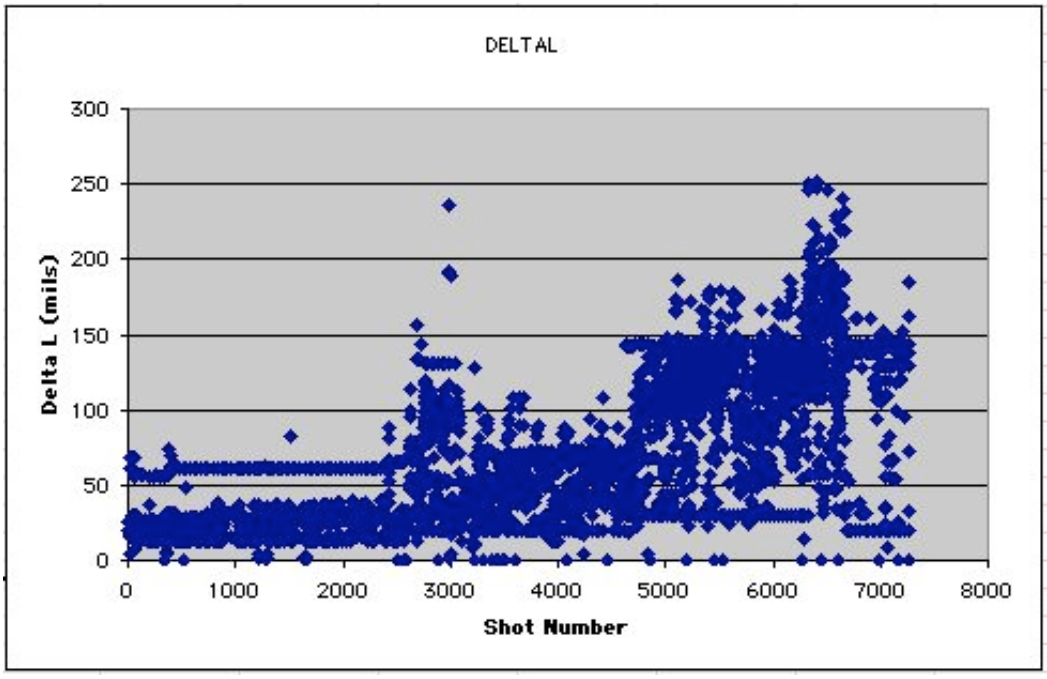
FROM: C NEUMEYER
SUBJECT: TF AXIAL THERMAL DISPLACEMENT AND SPLINE ACTION

The following table shows the maximum expected thermal displacement of the TF, which is of order 3/8" when the coil makes a temperature excursion from approx. 12ºC to 95ºC.

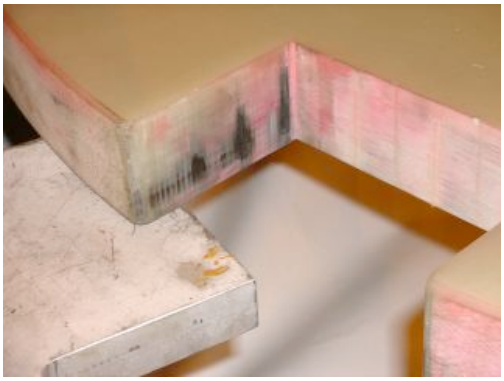
Cu Coeff of Expansion	1.69E-05	per degK
Troom	293.0	degK
Tmin	283.0	degK
Tmax	368.0	degK
Length at Troom	5.867	m
ΔL Cooldown	-0.001	m
	-0.039	in
ΔL Pulse	0.008	m
	0.332	in

Actual I2T dissipated in the TF coil, and thus the thermal displacements, has been less than that corresponding to the above. The following figure shows a histogram of the actual operating experience (calculated based on I2T), which has not approached the maximum allowable.

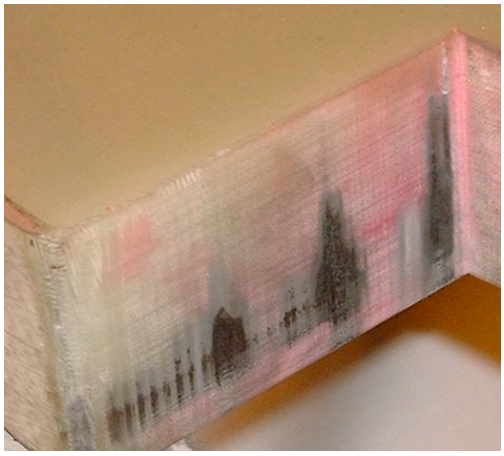


The spline at the top of the machine is designed to allow the above axial growth without imposing large stresses on the inner leg, while still providing a load path for the torsion on the inner leg due to the out-of-plane loads.

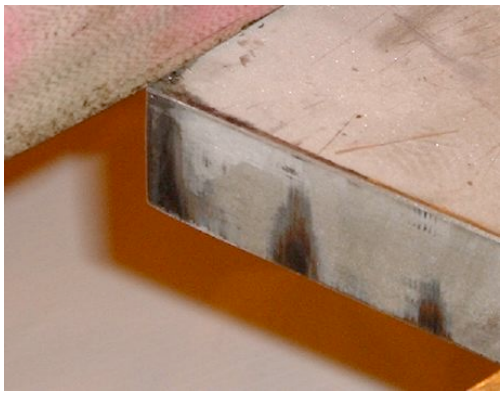
The following photos show evidence of abrasion/wear on the spline contact surfaces. To provide a sense of scale, the G10 piece is 2” thick.



Typical wear on G10



Zoom of typical wear on G10



Mating surface on umbrella steel

The pattern observed in these photos is typical for the spline surfaces which would engage with a counter-clockwise twist of the TF, viewed from above. There is also wear on the opposite surfaces, but it is less.

Since NSTX has run exclusively with Bt clockwise, and Ip counter-clockwise, the OH precharge magnetic field is such as to create JxB in the counter-clockwise direction. This is consistent with the observation of the wear, considering that OH always precharges to full field but usually does not swing fully in the opposite direction.

The wear pattern extends well beyond 3/8" in the vertical direction. No explanation is offered at this time.

The fact that some regions are darker than others is attributed to the lack of flatness on the mating surfaces.

An additional observation is that the spline is somewhat loose fitting. It can be placed in the engaged position without application of any force; there appears to be a gap of order 1/32" to 1/16". It may be desirable to develop some scheme for shimming to limit the angular twist before engagement occurs. The impact of this needs to be assessed by the finite element analysis. The present model assumes intimate contact. The case where a gap exists should also be investigated.

Cc:

A Brooks	J Chrzanowski	L Dudek	P Heitzenroeder	M Kalish
M Ono	J Schmidt	A Von Halle	M Williams	I Zatz