13_021106_CLN_01.doc

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FROM: C NEUMEYER
SUBJECT: ALTERNATE TF JOINT DESIGN FOR NSTX

Reference:

[1] 13_021011_CLN_01.doc, "Minutes Of Meeting On TF Flag Joints"

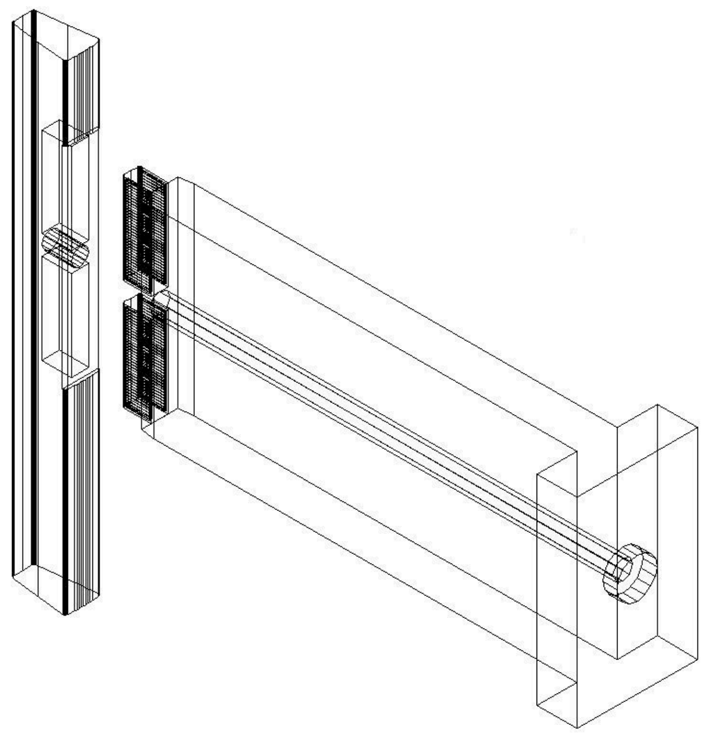
This memo presents an alternate design for the TF flag joints on NSTX.

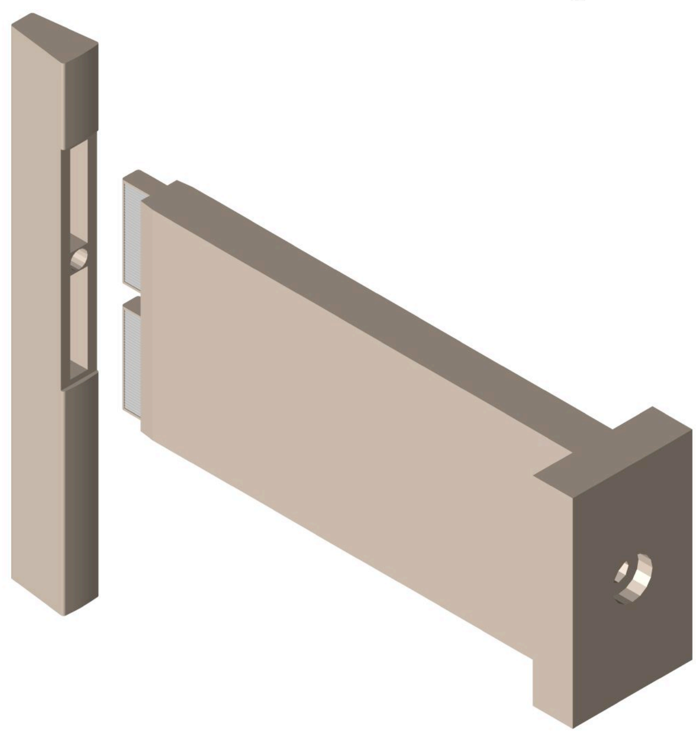
It can be implemented if a new inner leg assembly is fabricated, and if so will also require new flags. The same concept could be used for an NSTX center stack upgrade or for the NSST.

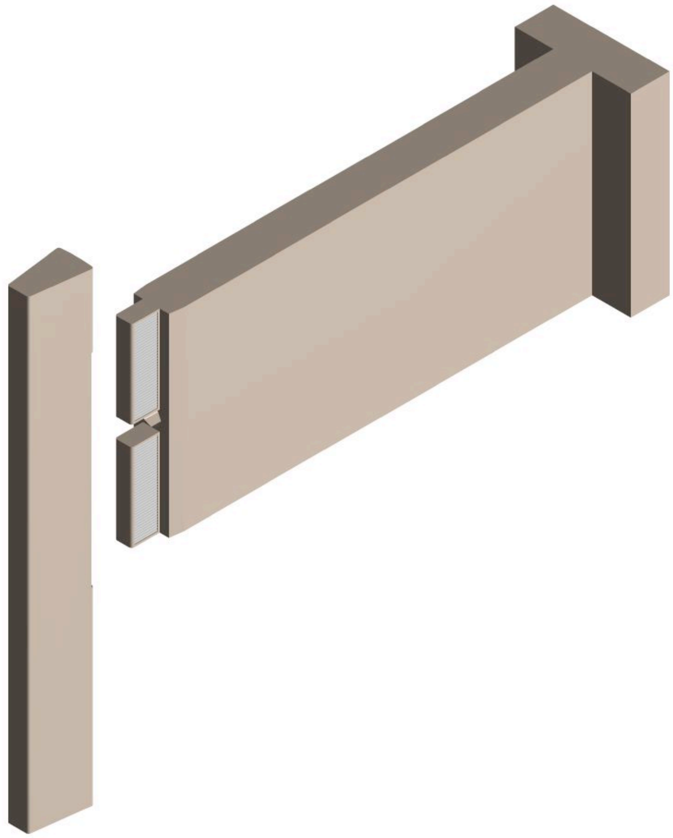
The joint relies on Multilam© contact technology. This involves louvered inserts which maintain many points of contact as a result of the spring action of the louvers. Current carrying capacity (ampacity) per unit area exceeds that available using ordinary bolted pressure contacts. The contact resistance and ampacity do not rely on surface flatness or smoothness and are essentially independent of the force applied to hold the joint together. Small deformations and displacements (e.g. due to thermal or mechanical forces) do not jeopardize the joint. These features can be exploited so as to provide a joint with ampacity exceeding that of the present joint, and less susceptibility to shortcomings in quality of fabrication and installation.

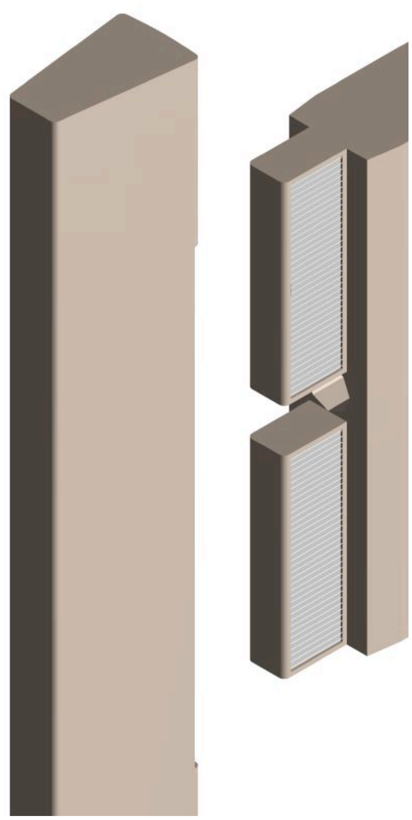
The new design would overcome the difficulties experienced with the existing design [1] which relies on high precision in terms of surface flatness and shoulder bolt fit-up as well as high bolting force, over the range of electromagnetic forces and temperatures experienced during operation. It is noted however, that good communication of the vertical force from the flag to the hub is still essential. This implies precise shimming (such as that being implemented now on NSTX repairs using inflatable shims) or other means (e.g. G-10 disks between the flag copper and hub, in lieu of the wrapped flag insulation and shims).

The jointing scheme is depicted in the following figures. It uses a "mortise-and-tenon" approach with Multilam located on the faces of the tenons. The mortise cut-outs are identical in width and depth to the holes drilled out in the present design for the Keenserts. A single set of bolting hardware is used, along the centerline of the flag. This consists of a threaded insert in the inner leg conductor (dimensions identical to the existing design), a threaded rod, and a spring washer/lockwasher/nut on the outboard end, accessed through a recessed counterbore. The rod is loose-fitting within the flag, in such a way that the upward vertical force on the flag is taken in shear redundantly by the tenons. The moment on the joint would be reacted to the hub by precision shimming.

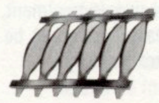
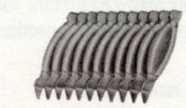
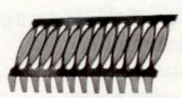








A catalog cut describing the Multilam part is given below.

The MC®-Multilam™ System For detailed information, use fax form on page 480 and check catalog: The MC-Multilam Principle.	Type	Width	Thickness	Louver spacing	Current per louver**	Short-circuit current per louver (duration 1 sec)**	Minimal diameters	Typical applications
		mm	mm	mm	A	kA	mm	
	LA0/0.15	26	0.15	5	30	0.38	25	large diameters, allowing for large tolerances, high continuous currents, low mating forces
	LA0/0.20	26	0.20	5	35	0.50	25	
	LA0/0.25	26	0.25	5	40	0.64	25	
	LA0/0.30	26	0.30	5	45	0.77	25	
	LA0-G	27	0.25	2.5	32	0.51	25	large diameters, allowing for large tolerances, very high continuous currents, low mating forces
	LAI/0.08	17.5	0.08	2.5	14	0.28	8	flat or round contacts, with dovetail groove or retaining rings, sliding and rotary contacts
	LAI/0.10	17.5	0.10	2.5	14	0.35	8	
	LAI/0.125	17.5	0.125	2.5	20	0.48	8	
	LAI/0.15	17.5	0.15	2.5	21	0.52	8	
	LAI/0.20	17.5	0.20	2.5	28	0.70	8	
	LAI/0.25	17.5	0.25	2.5	30	0.88	8	
	LAI/0.30	17.5	0.30	2.5	35	1.00	8	
	LAI/0.50	17.5	0.50	2.5	45	1.70	8	
	LAII/0.15	14	0.15	1.5	20	0.75	3.5	very high continuous and short circuit currents

The LAII/0.15 style is best suited to our purposes. The following calculation shows that the proposed design should have a good margin of safety in terms of ampacity. However, current bunching would tend to reduce this margin. On the other hand, the extrapolation to the 1.3 second pulse based on I^2T may be conservative because of the extra time for thermal effects to diffuse.

Louver Spacing	1.500	mm
1 sec current/louver	0.750	kA
Pulse current	71.200	kA
Pulse ESW	1.300	
I2T	6590.272	kA^2-sec
1 sec current	81.180	kA
# louver	108.241	louver
Min Length	162.361	mm
	6.392	in
Actual Length	8.600	in
	135%	

Before proceeding to implement this design it needs to be analyzed from mechanical and electrical perspectives. In addition, testing is essential.

Variants of the proposed design could be considered which might not require a new inner leg assembly or new flags. Smaller mortise-and-tenon geometries could be used which would allow the existing split flag configuration to be re-used, with two of the existing four bolts maintained. This would involve mortising on both the inner leg and flag sides, which would mean two joints instead of one. But if properly executed, this would not be a problem.

However, due to the reduced area of Multilam these variants would not have adequate ampacity, at least not per the catalog recommendation. Actual performance, which would have to be demonstrated by test, might be better.

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