

# NCSX CLOSE OUT NOTE: JOB 1501

**TO:** Phil Heitzenroeder  
**FROM:** Fred Dahlgren

**SUBJECT:** Coil Support Structure Job-1501

**Date:** 10/02/2008

## **Scope**

*This job covers the design and analysis of the structural supports for the TF & PF coils for NCSX, including the short column weldments which interface the core to the base support structure. Completion of this job is required prior to the start of component procurements in job 1553.*

## **Status**

*This job has completed an FDR and includes a complete set of drawings and bill of materials ready for procurement & fabrication as well as documentation of the analysis in support of the design.*

## **Interfaces**

*Key interfaces include the PF & TF coils, Trim coils, MCWF shell, C.S. support assembly, and base support structure. Undefined subsystems which will also interface with these supports include the cryogen supply and return manifolds, cryostat, and buswork supporting/mounting hardware for TF, PF, MC, and Trim coils. Other instrumentation leads TBD may also utilize portions of these support brackets.*

## **Specifications**

*NCSX-BSPEC-15-00*

A formal FMECA was not anticipated but a failure mode and mitigation plan was included in the PDR.

## **Schematics and PIDs**

*N/A*

## **Models**

The model supporting the analyses for the Coil Support Structure is provided in its native format as a backup to the calculation.

## **Drawings**

*Top Assembly Drawings:*

*se151-110-Rev0*

*se151-109-Rev0*

*se151-108-Rev0*

*se151-107-Rev0*

# NCSX CLOSE OUT NOTE: JOB 1501

*Note: detail drawings, and sub-assemblies can be found on the parts list of the main assemblies cited above or the full listing on the BOM.*

## **Analysis**

*NCSX-CALC-15-001-01*

## **Testing**

*The only testing performed was verification of magnetic permeability of commercially procured parts specified on the BOM. Samples of all parts specified meet the project permeability requirements in the locations they are to be used (as specified in the GRD).*

## **Costs**

*The initial budgetary quotes received for fabrication of this job are now 18 months out of date (as of 10/02/2008) and will need to be escalated based on current market conditions. This was done for the most recent Lehman review but would need to be re-visited were this project to be re-started. Hardware costs in the latest estimates (04/21/2008) are current as of that date as are material costs.*

## **Remaining Work**

Four chits from the PDR and 2 chits from the FDR remain unresolved pending input from other subsystems.

A detailed analysis of the local bolting stresses to resolve any issues there is also pending and would be required prior to fabrication.

## **Lessons Learned:**

The initial design for this job was well along (at or near the PDR stage) in the fall of CY'06 when I was first assigned to this task. This initial design, based on stainless steel castings, was tightly integrated into the overall machine core design and assembly plan, and provided a fairly robust solution for supporting the various coil systems. Some detailed drawings were already in progress. Unfortunately budgetary quotes received in Dec. '06 suggested the cost of castings was going to be significantly higher than had been previously estimated and budgeted for this sub-system, with quotes of 1.7-1.9M\$ vs. <1M\$ in the budget. To reduce costs a new design based on either aluminum or stainless weldments, was developed. While budgetary quotes received for the weldment design were significantly less than the castings, the added labor cost in design, drafting, and analysis for the new configuration probably diminished any savings over the casting design and required a significant effort in time and labor to update the CAD and FEA models. In retrospect it might have been more time conserving and cost effective to just re-baseline this job at the 2M\$ level and proceed with the casting option.

**Conclusion:** *A detailed analysis of the most critical bolted connections should be performed which could permit the use of 316 bolting hardware in many locations with Inconel 718 hardware used only where needed. This could reduce costs for bolting materials by 50% or more. Over 6 tons of 304L stainless remains in the PPPL materials yard and was earmarked for use on this job. The majority is 1/2" thick although some is*

## **NCSX CLOSE OUT NOTE: JOB 1501**

*5/8" Testing performed indicated all this material had a relative magnetic permeability of less than 1.02. Use of this yard material could save as much as 150K\$. Full solution annealing of 304L can lower the permeability of cold worked and welded 304L and should be considered if permeability issues arise.*

# **PF, TF, & Trim Coil Supports (WBS-15) Core Base Support Structure (WBS-17)**

F. Dahlgren

*NCSX Coil & Core base support structures*

# Requirements:



## PF, TF, Trim Coil Supports

The coil support structure provides the means for accurately locating and supporting the TF, PF, & Trim coils.

- It must provide adequate support for the EM loads arising from the coil operational scenarios and fault conditions.
- It must have sufficient compliance to accommodate cooldown from room temperature to 77 deg.K
- It must be sufficiently rigid to limit coil deflections to acceptable values per field error criteria.
- It must have a relative magnetic permeability less than 1.02
- It must limit eddy currents to effectively limit field errors at the plasma boundary.
- It must meet the NCSX seismic & Structural Design Criteria.



## Requirements:

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### Base Support Structure

Functional requirements:

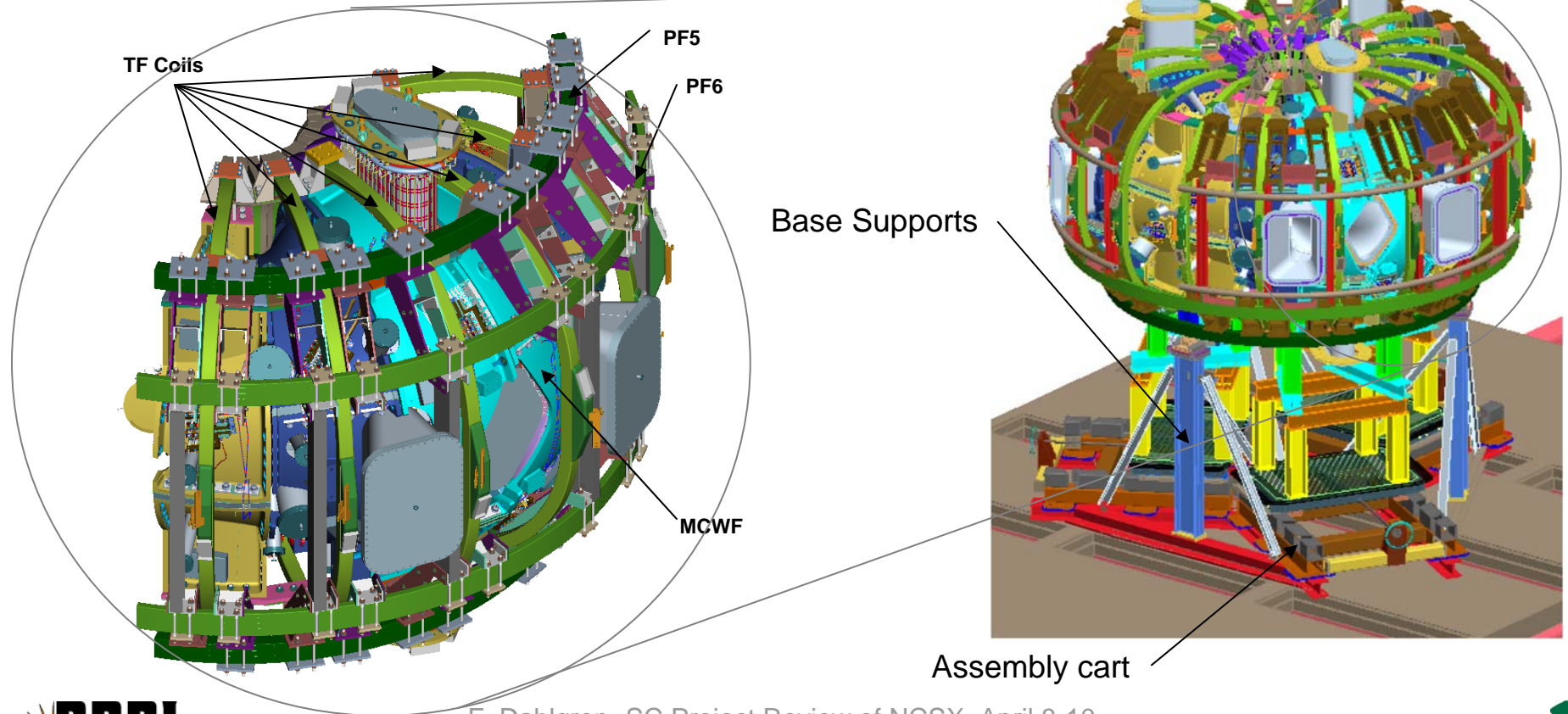
- Provides the gravity load path from the NCSX core to the test cell floor.
- It must not exceed the maximum test cell floor loading of 4,500 lbs/sq.ft.
- It must have a relative magnetic permeability less than 1.05
- It must meet the NCSX Structural Design & Seismic Criteria.
- It must provide support & clearance for the three period assembly tooling.

# Interfaces



## PF, TF, & Trim Coil Supports

The coil supports interface with the MCWF shell which provides the load path to react all coil EM and gravity loads. It will also interface with the mounting hardware for supporting the coil buswork, cryogen lines & cryostat.



# Interfaces

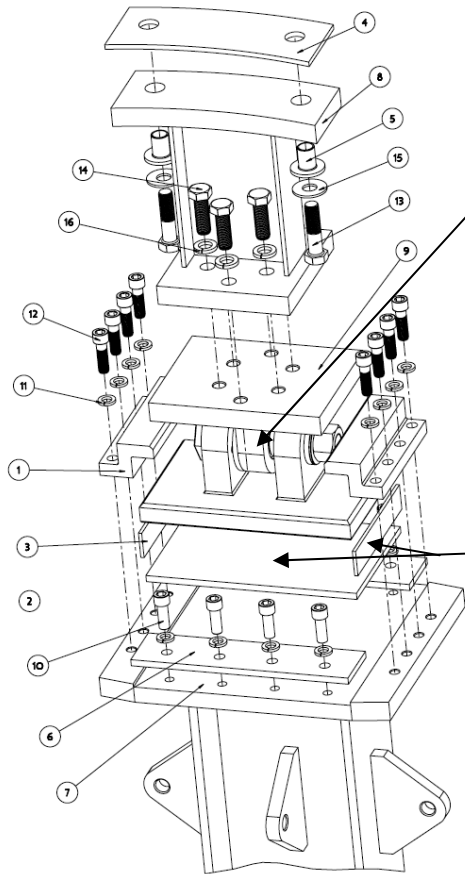
PF5 & 6 support brackets are cantilevered off the TF outer brackets





# Interfaces

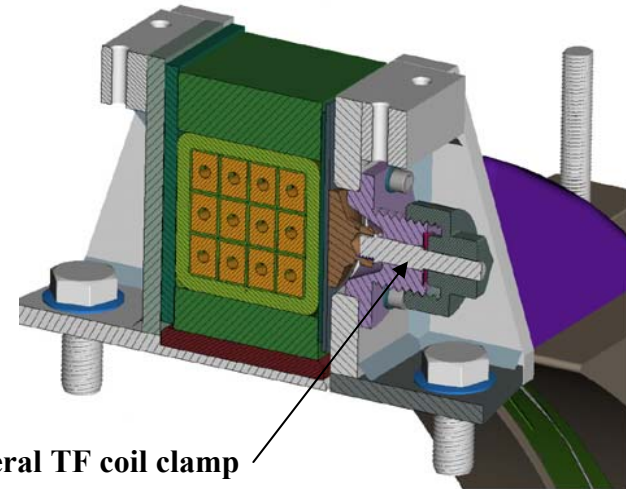
## The interface between the MCWF and Base Support columns



Spherical Bearings provide translational connections and avoid introduction of rotational moments on the MCWF shell.

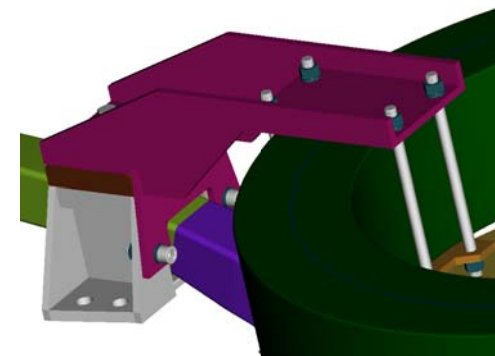
Low friction PTFE sheets provide a low compliance radial interface to allow for differential thermal contraction from room temperature base supports to 77 K core.

## TF Coil bracket & clamp interface



Lateral TF coil clamp

## PF4 Coil bracket & clamp interface



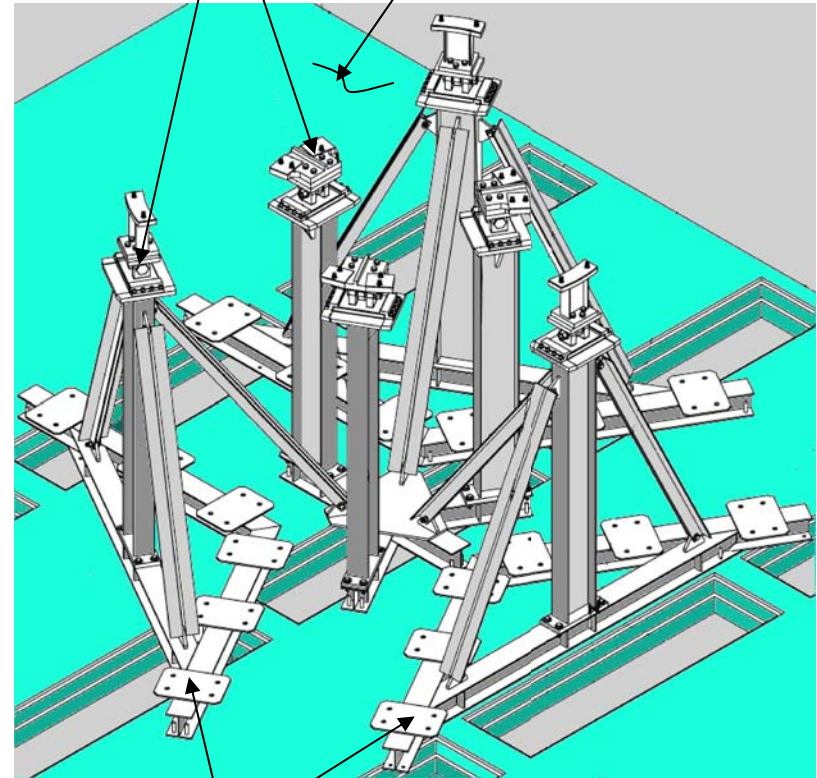
# Interfaces

## Base Support Structure

The base support structure interfaces with the test cell floor, and TF support brackets. It also provides the mounting pads for the three period assembly fixtures.

Spherical bearing Housings

Test cell floor  
(rated @ 4500 psf)



Mounting pads for 3-period assembly cart rails

# Design Status



## PF,TF, & Trim Coil Supports

- Peer review held on 01/18/07
- PDR held on 07/20/07
- FDR scheduled for 06/16/08
- Pro-E design integration complete.
- Preliminary drawings issued for review.
- Minor revisions being implemented to accommodate trim coil support mounting hardware.
- Design in final detailing awaiting interface information for buswork, cryogen lines, and cryostat mounting hardware.
- FEA modeling utilizing a single period fully integrated model is complete.
- FEA analysis of various EM and fault loading conditions is underway (~ 30% complete) with the fully integrated FEA model.



# Design Status



## Base Support Structure

- Peer review held on 01/18/07
- PDR held on 03/06/08
- FDR scheduled for 04/30/08
- Pro-E design integration complete.
- Preliminary drawings issued for review.
- Minor revision to accommodate cryostat interface underway.
- FEA modeling (w/testcell floor & structure) complete.
- FEA analysis complete.



# Procurement Plans



## PF,TF, & Trim Coil Supports

- Current plan for a fixed price subcontract.
- At least two potential vendors have been identified and budgetary estimates have been received.
- RFQ & CSPEC are being prepared, with a projected procurement cycle of 6 weeks starting mid-July '08 (subsequent to FDR).

## Base Support Structure

- Procure main columns & beams from Stainless Structural, LLC (~ 13 weeks)
- Fabricate parts in-house (welding, drilling, & assembly).



# Cost & Schedule - Coil Supports



## PF,TF, & Trim Coil Supports - Design

15 - Coil Structures								Cost to Complete	FY08			FY09			FY10			
Job: 1501 - Coil Structures Design-DAHLGREN																		
1501-533		Detail CAD Drawings,BOM	260*	01JUN07A	16JUN08	188	28,638.26											
1501-533F		Integrated Stress Analysis	176*	01OCT07A	16JUN08	188	27,007.75											
1501-536		Issue dwgs for review	0		01APR08*	215	0.00											
1501-535		Develop Interfaces with cryostat	0		01MAY08*	213	0.00											
1501-549		Update C.S.Support Attacgment Design	6	09MAY08	16MAY08	188	8,146.80											
1501-550		Peer review C.S.Design	5	19MAY08	23MAY08	188	1,168.88											
1501-554		Resolve CS peer review Chits	5	27MAY08	02JUN08	188	8,146.80											
1501-562		Prepare Specs for Coil Structure & CSS h/w	10	03JUN08	16JUN08	188	3,542.00											
1501-537		FDR Prep	6	09JUN08	16JUN08	188	3,515.48											
1501-541	3	Coil Support Structures - FDR	0		16JUN08	188	0.00											
1501-545		Resolve Chits	5	17JUN08	23JUN08	188	5,844.40											
1501-558		Prepare requisition for Coil Structure & CSS h/w	10	24JUN08	08JUL08	188	3,542.00											

## PF,TF, & Trim Coil Supports - Fabrication/Procurement

Job: 1550 - Coil Struct. Procurement -PERRY								Cost to Complete	FY08			FY09			FY10			
1501-245		Solicit Bids, and Evaluate Bids	35	09JUL08	26AUG08	188	0.00											
162-036.9	2	Award Coil Support Structure	0		02SEP08*	184	0.00											
162-037		Fabricate structure components	100	03SEP08	02FEB09	184	1,142,011.99											
162-037M	2	Deliver Coil Structure components	0		02FEB09	184	0.00											
162-050		Prep req, bid and award G11/Teflon parts	25	01OCT08*	04NOV08	149	0.00											
162-051		Deliver G11/Teflon parts	90	05NOV08	23MAR09	149	153,879.66											
162-052		Prep req, bid and award Inconel hardware	25	01OCT08*	04NOV08	179	0.00											
162-053		Deliver Inconel hardware	60	05NOV08	09FEB09	179	106,586.37											
162-055		Prep req, bid and award Belleville Washers	25	01OCT08*	04NOV08	149	0.00											
162-057		Deliver Belleville Washers	90	05NOV08	23MAR09	149	24,422.20											
162-031		Title III engr WBS 151	117	03SEP08*	25FEB09	1,424	12,091.25											

**Total: 1,439k\$ (FY'09)**



F. Dahlgren -SC Project Review of NCSX, April 8-10, 2008



# Cost & Schedule - Base Support Structure



## Base Support Structure - Design

Activity ID	MILE-STONE LEVEL	Activity Description	Duration (work days)	SHIFTS	Forecast Start	Forecast Finish	Total Float	Cost to Complete	FY		
									FY08	FY09	FY10
<b>17 - Cryostat and Base Support Structure</b>											
<b>Job: 1702 - Base Support Struct Design-DAHLGREN</b>											
1702-515	3	Base support - PDR	5	R	31JAN08	06FEB08	202	3,506.64			
1702-516	3	Disposition PDR chits	5	R	07FEB08	13FEB08	202	2,833.60			
1702-520		Final design. Assy dwgs, fab dwgs,	64*		01FEB08A	30APR08	147	127,230.72			
1702-521	2	Issue dwgs for comment	0			28MAR08*	170	0.00			
1702-525M	2	Base Support Structure FDR	0			30APR08	147	0.00			
1702-530		Resolve chits, issue dwgs for fab, issue requisit	10		01MAY08	14MAY08	147	8,430.08			

DAHLGREN =04hr ;  
 DAHLGREN =04hr ;  
 DAHLGREN =448hr ; CRUIKSHANK =224 ;  
 DAHLGREN=32;CRUIKSHANK=24

## Base Support Structure - Fabrication

<b>Job: 1752 - Base Support Proc-PERRY</b>											
<b>172 - Base Support Structure</b>											
161-036.8	3	Bid and award base support materials	30		19AUG08*	30SEP08	177	0.00			
161-036.9	3	Deliver base support materials	130		01OCT08	13APR09	177	192,190.96			
161-037		PPPL assemble structure	40		14APR09*	09JUN09	177	30,335.91			
161-038		Title III	306		15MAY08*	05AUG09	1,311	7,037.18			

41=147,156\$;  
 EMT/TB =363 ;  
 PERRY=44

**Total: 229.5 k\$  
(FY'09)**





# Risks & Mitigation

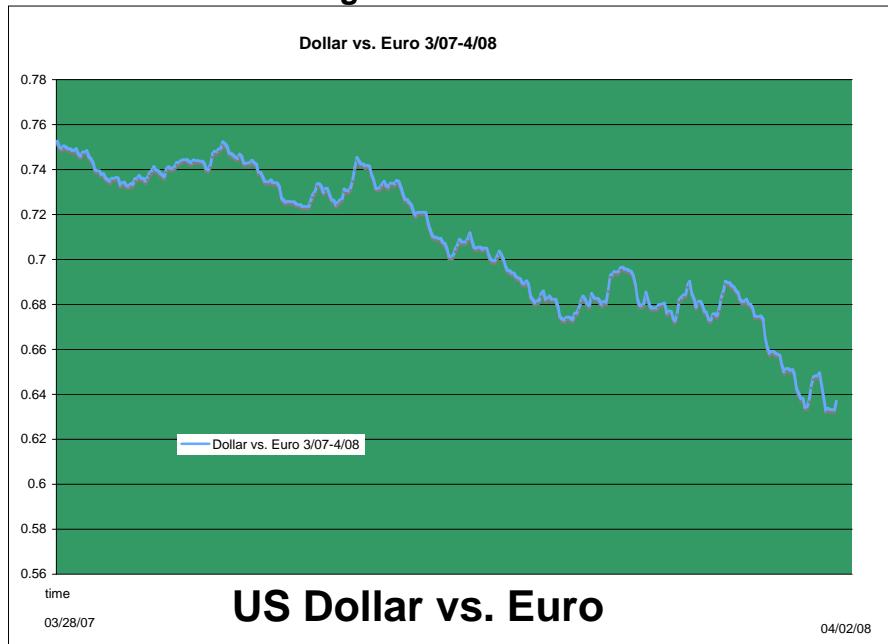


## PF,TF, & Trim Coil Supports & Base Support Structure

Both these jobs are comprised of conventional weldments and bolted assemblies. As such they are classified as relatively low risk components with minimal probability of cost escalation or scheduler delay associated with their procurement and fabrication.

### Risk:

The main source of cost escalation would be tied to increased commodity prices for Nickel and Molybdenum and the weakening value of US dollar vs. the Euro.



QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.

## Nickel Price Since January

### Mitigation:

Expedite procurement of stainless structurals and Inconel hardware.



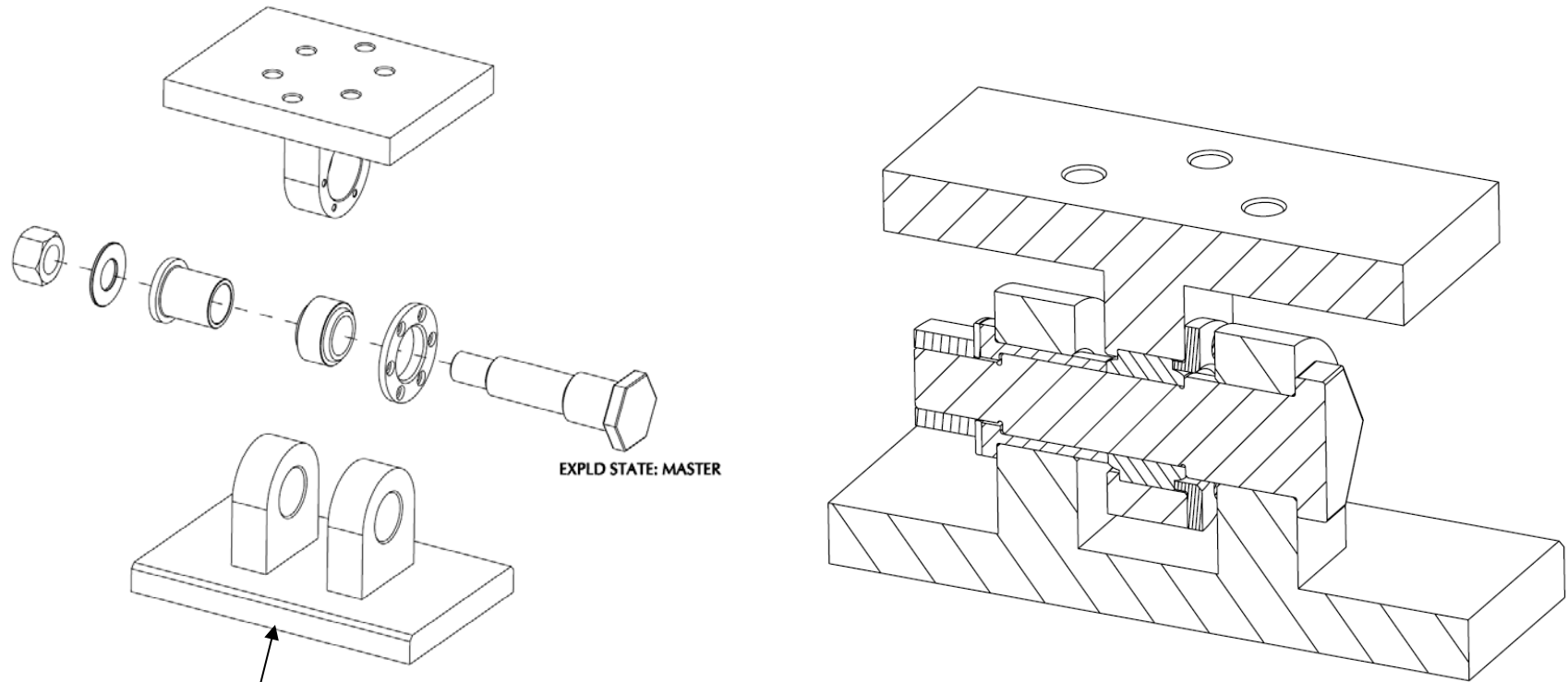


# Backup slides

QuickTime™ and a  
TIFF (LZW) decompressor  
are needed to see this picture.



Strip heaters (4 per column) will be used to maintain R.T. (40 to 60 F) of columns



EXPLD STATE: MASTER

Bottom surface slides on Teflon sheet

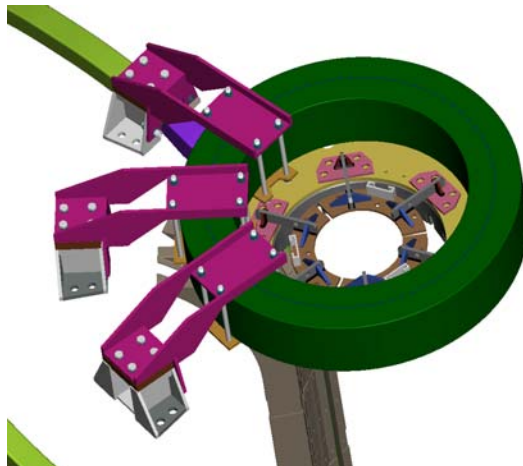


TF Inner Supports "B" to "C" Span

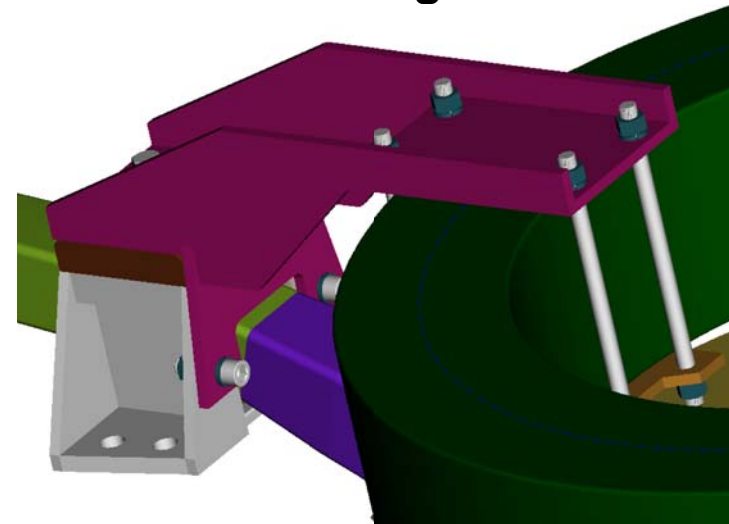


TF Outer Supports "C" to "B" Span

### Inner TF coil mtg. brkts.

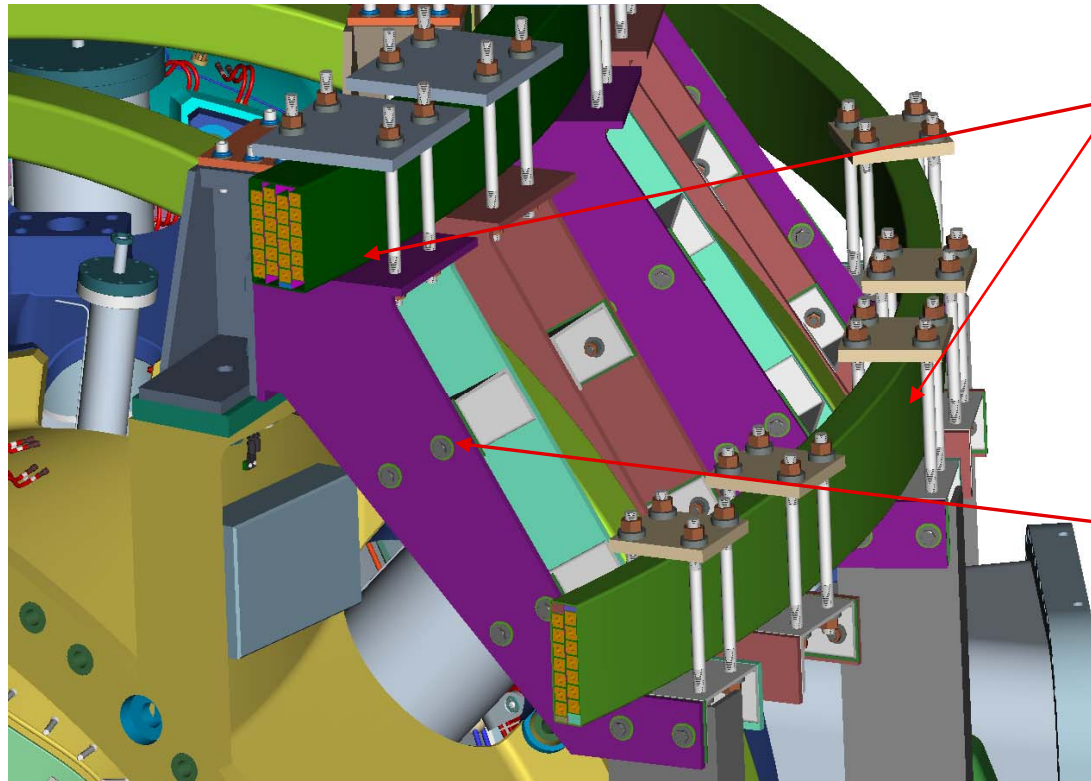


### Outer TF Coil mtg. brkts.



### PF4 Coil Mtg. off inner TF brkts.

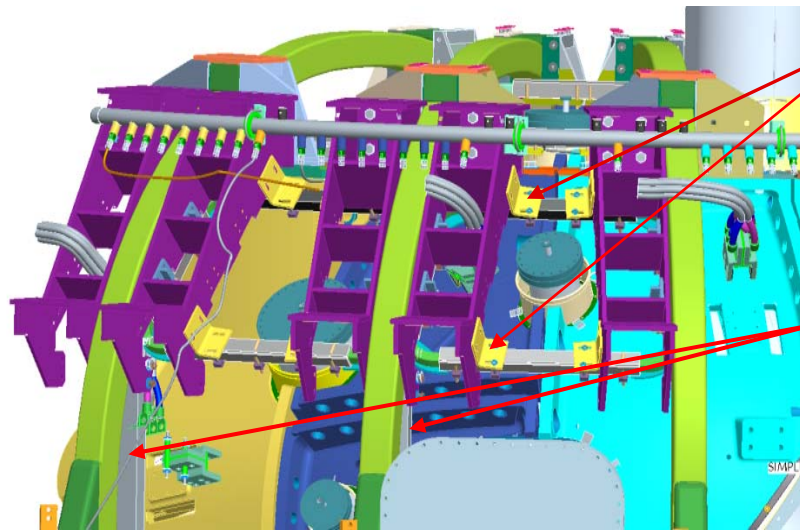
F. Dahlgren -SC Project Review of NCSX, April 8-10, 2008



PF5&6 are shimmed & clamped. Brackets are cantilevered off the outer TF bracket assembly.

All bolted Joints on bracket bracing are now welded.

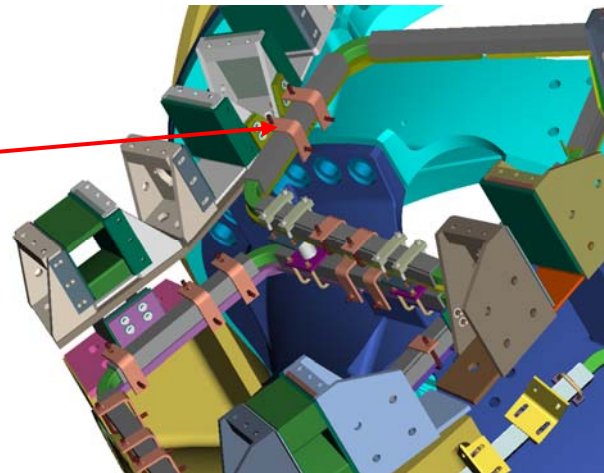
PF Coils are shimmed & clamped to the support brackets



Trim coils mount to PF5 &6 cantilevered bracket assemblies.

Vertical channels provide additional support between the top and bottom brackets.

Inbd. Trim coils mount to TF-bracket assemblies.



Trim Coils are shimmed & clamped to the support brackets



# PF-TF Coil Supports -Cost estimate breakdown

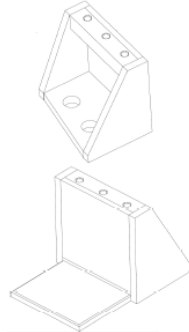


NCSX Coil Support Structure – 1501/1550 Re-baseline estimate – Rev.K 2 April 2008

## 1. Inner TF support Structure

### 1a. Supp't brkts. (72 req'd.)

Cutting & machining	6.0 hrs x \$92.00 = \$552.00
Weld prep & weld	2.2 hrs x 76.00 = 167.20
Clean-up de-scale de-burr	0.5 hrs x 76.00 = 38.00
Mat'l.: 304ss plate	120 lbs. x 6.90 = 828.00



### \*1b. G11-CR Mtg. blocks (36 req'd.)

Cutting & machining (2 pcs.)	2.5 hrs x \$92.00 = \$230.00
Epoxy adhesive bond to coil	0.5 hrs x \$75.00 = 37.50
Mat'l.: G11-CR plate \$48.00 per pc.	2 pcs. x \$48.00 = 96.00

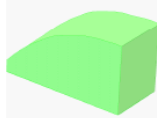
### \*1c. G11-CR Side Wedge Shims (4 pcs. Req'd per set x 36 sets)

Cutting & Machining wedges	3.0 hrs. x \$92.00 = \$276.00
Mat'l.: G11-CR plate \$42.00 per pr.	2 pcs. x 42.00 = 84.00
Teflon pads 1/8" thk.	2 pcs x 27.00 = 54.00



### \*\*1d. Inconel Hardware (36 sets Req'd.)

(4) 1-8 N.C. x 2.5" Hex Head Bolts	4 pcs. x \$50.40 = \$201.60
(4) 1" Flat Washer – Heavy Series	4 pcs. x 3.65 = 14.60
(4) 1" Lock Washer	4 pcs. x 2.95 = 11.80
(6) 1/2 -13 N.C. Hex Head Bolts	6 pcs. x 19.80 = 118.80
(6) 1/2" Flat Washers – Heavy Series	6 pcs. x 2.65 = 15.90
(6) 1/2" Split Lock Washer	6 pcs. x 2.10 = 12.50



### 1e. T.F. Bridge Clamp (36 Req'd)

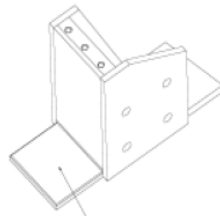
Cutting & machining	3.0 hrs x \$92.00 = \$276.00
Mat'l.: 304 ss plate	36.0lbs x 6.90 = 248.40

### \*1f. PFTE coated G11-CR wedge assemblies (72 Req'd.)

Cutting & machining	2 pcs. x 3.0 hrs x 92.00 = 550.00
Teflon coating	2 pcs @ \$40.00/pc. = 80.00

### 1g Lateral TF pre-load (36 req'd.)

TF preload ass'y	1,740 per ass'y.= 1,740.00
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## 2. Outer TF support Structure

### 2a. Supp't brkts. (72 req'd.)

Cutting & machining	7.5 hrs x \$92.00 = \$690.00
Weld prep & weld	2.5 hrs x 76.00 = 190.00
Clean-up de-scale de-burr	0.5 hrs x 76.00 = 38.00
Mat'l.: 304 ss plate plate	165 lbs. x 6.90 = 1138.00

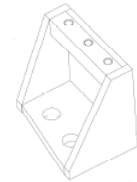
### \*2b. G11-CR Mtg. blocks (36 req'd.)

Cutting & machining (2 pcs.)	2.5 hrs x \$92.00 = \$230.00
Epoxy adhesive bond to coil	0.5 hrs x \$75.00 = 37.50
Mat'l.: G11-CR plate \$48.00 per pc.	2 pcs. x \$48.00 = 96.00

## Outer TF support Structure (con't.)

### \*2c. G11-CR Side Wedge Shims (4 pcs. Req'd per set x 36 sets)

Cutting & Machining wedges	3.0 hrs. x \$92.00 = \$276.00
Mat'l.: G11-CR plate \$42.00 per pr.	2 pcs. x 42.00 = 84.00
Teflon pads 1/8" thk.	2 pcs x 27.00 = 54.00



### \*\*2d. Inconel Hardware (36 sets Req'd.)

(4) 1-8 N.C. x 2.5" Hex Head Bolts	4 pcs. x \$50.40 = \$201.60
(4) 1" Flat Washer – Heavy Series	4 pcs. x 3.65 = 14.60
(4) 1" Lock Washer	4 pcs. x 2.95 = 11.80
(6) 1/2 -13 N.C. Hex Head Bolts	6 pcs. x 19.80 = 118.80
(6) 1/2" Flat Washers – Heavy Series	6 pcs. x 2.65 = 15.90
(6) 1/2" Split Lock Washer	6 pcs. x 2.10 = 12.50

### 2e. T.F. Bridge Clamp & pre-load ass'y. (36 Req'd)

Cutting & machining	3.0 hrs x \$92.00 = \$276.00
Mat'l.: 304 ss plate plate	36.0lbs x 6.90 = 248.40
Lateral TF preload ass'y (36 req'd.)	1,740 per ass'y.= 1,740.00

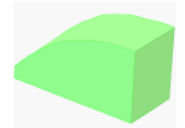


### \*2f. PFTE coated G11-CR wedge assemblies (72 Req'd.)

Cutting & machining	2 pcs. x 3.0 hrs x 92.00 = 550.00
Teflon coating	2 pcs @ \$40.00/pc. = 80.00

### 1g Lateral TF pre-load (36 req'd.)

TF preload ass'y	1,740 per ass'y.= 1,740.00
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## 3. PF5/PF6 Support Brkt. Ass'y. (66 Req'd.)

### 3a Bracket Ass'y (66 Req'd.)

Cutting & Machining	12.0 hrs x \$92.00 = \$1104.00
Weld prep & weld	6.5 hrs x 76.00 = 494.00
Clean-up de-scale de-burr	1.5 hrs x 76.00 = 114.00
Mat'l.: 304 ss plate plate	120.0lbs x 6.90 = 828.20

### 3b. P.F. 5 Bridge Clamps (66 Req'd)

Cutting & machining	3.0 hrs x \$92.00 = \$276.00
Mat'l.: 304 ss plate plate	36.0lbs x 6.90 = 248.40

### 3c. P.F. 6 Bridge Clamps (66 Req'd)

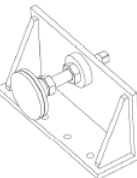
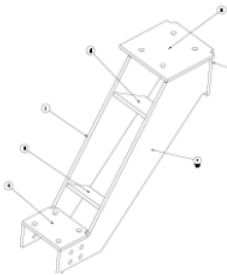
Cutting & machining	3.0 hrs x \$92.00 = \$276.00
Mat'l.: 304 ss plate plate	36.0lbs x 6.90 = 248.40

### \*\*3d. Inconel Hardware (66 sets Req'd.)

(4) 3/4-10 N.C. x 8.5" Hex Head Bolts	4 pcs. x \$ 68.90 = \$275.60
(4) 3/4-10 N.C. x 9.5" Hex Head Bolts	4 pcs. x 73.90 = 295.60
(4) 3/4-10 N.C. Hex Nuts	4 pcs. x 24.80 = 99.20
(8) 1" Flat Washer – Heavy Series	8 pcs. x 3.65 = 29.20
(8) 1" Lock Washer	8 pcs. x 2.95 = 23.80

### 3e Positioning Brkt. Ass'y. (21 Req'd)

Cutting & Machining	8.0 hrs x \$92.00 = \$ 736.00
Weld prep & weld	2.5 hrs x 76.00 = 190.00
Clean-up de-scale de-burr	1.5 hrs x 76.00 = 114.00
Mat'l.: 304 ss plate plate	105.0lbs x 6.90 = 724.50



# PF-TF Coil Supports -Cost estimate breakdown -con't.



## 4. PF5/PF6 Support Frame Ass'y Long Span (6 Ass'y. Req'd)

4a. Vertical channels (For 3 -Req'd. per ass'y)

Cutting & Machining	2.0 hrs x \$92.00 = \$184.00
Clean-up de-scale de-burr	0.8 hrs x 76.00 = 60.80
Mat'l: 304 ss channel	44.0lbs x 8.50 = 374.00

\*\*4b. Inconel Mtg. Hardware (6 sets of 4 per ass'y)

(4) 1/2 -13 N.C. Hex Head Bolts	4 pcs. x 24.50 = 98.00
(4) 1/2 -13 N.C. Hex Nuts	4 pcs. x 16.80 = 67.20
(4) 1/2" Flat Washers - Heavy Series	4 pcs. x 2.65 = 10.60
(4) 1/2" Split Lock Washer	4 pcs. x 2.10 = 8.40



## 5. PF5/PF6 Support Frame Ass'y Short Span (6 Ass'y. Req'd)

5a. Vertical channels (For 3 -Req'd. per ass'y)

Cutting & Machining	2.0 hrs x \$92.00 = \$184.00
Clean-up de-scale de-burr	0.8 hrs x 76.00 = 60.80
Mat'l: 304 ss channel	44.0lbs x 8.50 = 374.00

\*\*5b. Inconel Mtg. Hardware (3 sets of 4 per ass'y)

(4) 1/2 -13 N.C. Hex Head Bolts	4 pcs. x 24.50 = 98.00
(4) 1/2 -13 N.C. Hex Nuts	4 pcs. x 16.80 = 67.20
(4) 1/2" Flat Washers - Heavy Series	4 pcs. x 2.65 = 10.60
(4) 1/2" Split Lock Washer	4 pcs. x 2.10 = 8.40



\$30.60 Inco purchased pt.
Solon Washer \$7.95
10 hr x 81 = \$810
4 hr x 81 = \$360
6 hr x 81 = \$540
<b>Total: \$ 1,748.56</b>

Supplemental parts Inner & Outer TF Lateral Pre-load: \$125,876

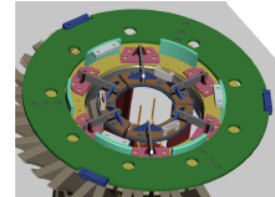
## 6. TF Pre-load Ring & PF4 Support Brkts (2 rings, 2 sets of brkts.)

6a. Base Ring

Castings	355 lbs x \$35.00 = \$12,425.00
Machining	120 hrs x 92.00 = 11,040.00

6b. PF4 Brkts Inco plate weldments - (6 Top & 6 Bottom)

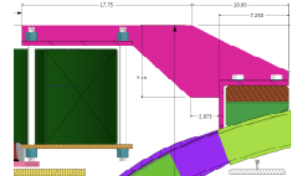
(6) Cutting & Machining	2.5 hrs x 6 x \$92.00 = \$1380.00
(6) Weld prep & weld	1.5 hrs x 6 x 76.00 = 684.00
(6) Clean-up de-scale de-burr	3.0 hrs x 6 x 76.00 = 228.00
(6) Mat'l: Inconel 625 plate	41.0lbs x 28.50 = 1168.50



## 7. C.S. Coil mtg. brkts. (2x=12 brkts total)

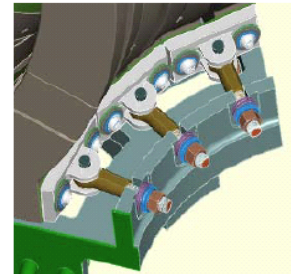
7a. Inconel Suppt't brackets (2 sets Req'd - 6 Top & 6 Bottom)

(6) Cutting & Machining	6.5 hrs x 6 x \$92.00 = \$3588.00
(6) Weld prep & weld	2.5 hrs x 6 x 76.00 = 1140.00
(6) Clean-up de-scale de-burr	3.0 hrs x 6 x 76.00 = 228.00
(6) Mat'l: Inconel 625 plate	67.0lbs x 6 x 28.50 = 11,336.40



\*\*7b. Inconel Mtg. Hardware (6 sets of 4 per ass'y)

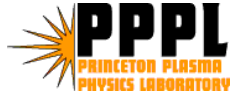
(4) 1/2 -13 N.C. Hex Head Bolts	4 pcs. x 24.50 = 98.00
(4) 1/2 -13 N.C. Hex Nuts	4 pcs. x 16.80 = 67.20
(4) 1/2" Flat Washers - Heavy Series	4 pcs. x 2.65 = 10.60
(4) 1/2" Split Lock Washer	4 pcs. x 2.10 = 8.40



## 8. T.F. Pre-load clamp Assemblies

8a. Stellite casting (36 Required) ..... \$350.00 x 36 = 12,600.00

(36) Inco 3/4 -10NC Pivot Bolt. 1.25 grip 41.50 x 36 =	1,494.00
(36) Inco 3/4 -10NC Hex Nut ..... 24.80 x 36 =	892.80
(72) Inco 1/2 -13NC Hex Head Bolt ..... 16.80 x 72 =	1,209.60
(72) Inco 1/2" Flat Washers ..... 2.65 x 72 =	190.80
(72) G11-CR Washer ..... 1.40 x 72 =	100.80
(72) G11-CR Sleeve ..... 2.50 x 72 =	180.00
(36) Inco 3/4 -10NC" Jack Nut ..... 28.50 x 36 =	1,026.00
(36) Inco 3/4" Swivel Eye-Bolt ..... 51.50 x 36 =	1,854.00
(36) G11-CR 1/4" thk. Insul. Pad ..... 18.50 x 36 =	666.00





# PF-TF Coil Supports -Cost estimate breakdown -con't.



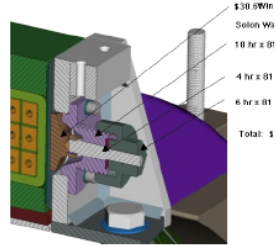
## 9. P.F. 4 Bridge clamps (12 req'd.)

- 9a. (1) C & M Plates 6" x 6" x 3/4".....4.5 hrs x 1 x \$92.00 = 414.00
- 9b. Clean-up de-scale de-burr .....1.5 hrs x 76.00 = 114.00
- \*\*9c. Inconel Hardware
  - (4) 1/2 -13 N.C. Hex Head Bolts .....4 pcs. x 24.50 = 98.00
  - (4) 1/2 -13 N.C. Hex Nuts .....4 pcs. x 16.80 = 67.20
  - (4) 1/2" Flat Washers – Heavy Series .....4 pcs. x 2.65 = 10.60
  - (4) 1/2" Split Lock Washer .....4 pcs. x 2.10 = 8.40
- \*9d. (1) G11-CR 1/4" thk. Insul. Pad .....18.50 = 18.50
- \*9e. (2) Teflon pads .....2 pcs. x 27.00 = 54.00
- 9f. 6 x 6 x 3/4" thick Inconel601 plate.....27.0lbs x 22.50 = 607.50



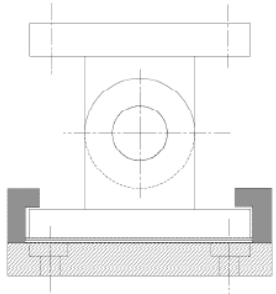
## 10. Inner & outer spacer blocks MCWF-TF supp't brkts (24 Req'd.)

- 10a. C & M blocks.....10hrs x 92.00 = 920.00
- 10b. Clean-up, de-scale & de-burr.....1.5 hrs x 92.00 = 138.00
- \*\*10c. (4) Inco 3/4 -10NC Hex Bolt .....4.25 grip 64.90 x 4 = 259.60
- \*\*10d. (4) Inco 3/4" Flat Washers .....3.40 x 4 = 13.60
- 10e. 304 ss 6" x 6" x 3" thick.....32lbs ea. x \$6.90 = 220.00
- 10f. Lateral TF preload ass'y.....1,740 per ass'y = 1,740.00



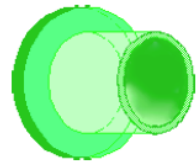
## 11. Machine/base support Interface (6 Req'd.)

- 11a. C & M plates .....(11 parts) 80 hrs x 92.00 = 7,360.00
- 11b. Weld Clevises & side plates .....16 hrs x 75.00 = 1,200.00
- 11c. Clean-up, de-scale & de-burr.....4 hrs x 92.00 = 368.00
- 11c. Spherical Bearings .....1 x 2850.00 = 2850.00
- \*11e. C & M G11 & Teflon sheets .....8 hrs x 92.00 = 736.00
- 11f. Inco 625 plates & rnd. Bar.....144 lbs x 28.50 = 4,104.00
- \*11g. G11-CR Plate .....10" x 10" x 1" = 158.00
- \*11h. Teflon sheet .....8" x 8" x .13" = 56.00
- \*\*11i. Inconel Hardware (2 sets Req'd.)
  - (4) 1-8 N.C. x 2.5" Hex Head Bolts .....4 pcs. x \$50.40 = \$201.60
  - (4) 1" Flat Washer – Heavy Series .....4 pcs. x 3.65 = 14.60
  - (4) 1" Lock Washer .....4 pcs. x 2.95 = 11.80



## 12. Misc. Assembly Hardware

- 12a. G11 bushings TF clamps .....360 x 2.50 = 900.00
- 12b. G11 washers TF clamps .....360 x 0.80 = 288.00
- 12c. G11 bushings Frame Assy' .....168 x 2.50 = 420.00
- 12d. G11 washers PF Clamps .....168 x 0.80 = 134.40
- 12e. G11 bushings PF Clamps .....168 x 2.50 = 420.00
- 12f. G11 washers Frame Ass'y .....168 x 0.80 = 134.40
- 12g. G11 bushings M/B interface .....24 x 2.50 = 60.00
- 12h. G11 washers M/B interface .....24 x 0.80 = 19.20
- \*\*12i. Inconel 718 .75 ID B'ville washers.....720 x 12.50 = 9,000.00
- \*\*12j. Inconel 718 1.03 ID B'ville washers...360 x 26.93 = 9,694.80



1. Inner TF Support Structure (36)		
1a	I-C&M432	\$67,651.40
1b		\$13,086.00
1c		\$14,904.00
1d		\$13,507.20
1e	I-C&M108	\$11,906.00
1f		\$45,360.00
1g		\$62,640.00
1h		\$3,600.00
1i		\$4,500.00
2. Outer TF Support Structure (36)		
2a	I-C&M540	\$84,154.00
2b		\$13,086.00
2c		\$14,904.00
2d		\$13,507.00
2e	I-C&M108	\$11,906.00
2f		\$45,360.00
2g		\$62,640.00
2h		\$3,600.00
2i		\$4,500.00
3. PF6 Support Bracket Assembly (66)		
3a	I-C&M504	\$149,107.00
3b	I-C&M108	\$21,828.00
3c	I-C&M108	\$21,828.00
3d		\$47,749.40
3e	I-C&M168	\$25,190.00
3f	I-C&M40	\$7,800.00
4. PF6 Support Frame Assembly \$ Long (6)		
4a	I-C&M12	\$3,712.80
4b		\$8,842.00
5. PF6 Support Frame Assembly \$ Short (3)		
5a	I-C&M12	\$3,712.80
5b		\$4,420.90
6. TF Pre-Load Ring & PF4 Support (2)		
6a.	I-C&M240	\$46,930.00
6b	I-C&M15	\$6,920.00
7. C.S. Coil Mounting Brackets (12)		
7a	I-C&M78	\$33,584.00
7b		\$2,210.40
8. TF Coil Pre-Load Clamp Assemblies (36)		
8a		\$37,054.50
9. PF4 Coil Mounting Clamp (12)		
9a	I-C&M54	\$4,968.00
9b		\$1,368.00
9c		\$2,210.40
9d		\$222.00
9e		\$648.00
9f		\$7,295.00
10. MCWF-TF Mtg. Brkt. Spacer block & shim		
10a I-C&M240		\$22,080.00
10b		\$3,312.00
10c		\$6,230.40
10d		\$326.40
10e		\$21,888.00
11. Machine/Base Support Interface		
11a I-C&M240		\$44,160.00
11b		\$7,200.00
11c		\$2,208.00
11d		\$14,544.00
11e		\$4,416.00
11f		\$14,544.60
11g		\$5,968.00
11h		\$336.00
11i		\$10,368.40
12. Misc. Assembly Hardware		
12a		\$900.00
12b		\$288.00
12c		\$420.00
12d		\$134.40
12e		\$420.00
12f		\$134.40
12g		\$60.00
12h		\$19.20
12i		\$9,000.00
12j		\$9,694.80
subtotal		\$1,106,064.60
50% ss mat'l allowance		\$28,808.00
scrap value		-\$6,680.00
M&S Total		\$1,128,192.60
Insp.,Pkging.,Shipping		\$25,000.00
Total FOB Plainsboro,NJ		\$1,153,192.60



# PF-TF Coil Supports -Cost estimate breakdown -con't.



**Cost estimates are based primarily on budgetary quotes from prospective vendors:**

PASSAIC COUNTY WELDERS, INC. - QUOTE RECEIVED: 2 MAY 2007

QTY		UNIT COST	TOTAL	NET UNIT WEIGHT	TOTAL WEIGHT
6	REQD---PF-6 VERTICAL STIFFENER DWG. SE151-152 REV O.	\$ 1,645.00	\$ 9,870.00	41.1	246.6
12	REQD---PF-6 VERTICAL STIFFENER DWG. SE151-153 REV O.	\$ 1,310.00	\$ 15,720.00	44.0	528.0
6	REQD---PF-6 SUPPORT ARC DWG. SE151-156 REV O.	\$ 2,471.00	\$ 14,826.00	54.4	326.4
12	REQD---PF-6 SUPPORT ARC DWG. SE151-160 REV O.	\$ 3,253.00	\$ 39,036.00	107.5	1,290.0
42	REQD---PF-5 & PF-6 SUPPORT BRACKET DWG. SE151-175 REV O.	\$ 3,204.00	\$ 134,568.00	113.7	4,775.4
72	REQD---COIL REAR LEFT SUPPORT DWG. SE151-177 REV O.	\$ 1,552.00	\$ 111,744.00	46.3	3,333.6
72	REQD---TF COIL FRONT LEFT BRK. DWG. SE151-179 REV O.	\$ 1,424.00	\$ 102,528.00	33.2	2,390.4
		<b>SUB-TOTAL</b>	<b>\$ 428,292.00</b>		12,890.4
	FOB WAYNE,NJ.			ADJUST WT. 72-RH BRKTS.	(792.0)
	THIS ESTIMATE WAS FOR 316L SOLUTION ANNEALED PLATE				12,098.4

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

ESTIMATE FOR COST DELTA FOR INCONEL 601: @22.50/LB \$ 217,771.20  
 SHIPPING, PACKAGING & INSPECTION \$ 15,000.00  
 TOTAL ADJUSTED COST FOR ITEMS 1 THRU 7 \$ 681,063.20

MY ESTIMATE FOR 7 ITEMS 1A,2A,3A,4A,4B,5A,5B +S,P&I \$ 628,765.00 -5% LOWER

**NOTE: QUOTE FOR 7 ITEMS ONLY TF & PF5&6 BRACKETRY**  
 NO HARDWARE, INSULATORS, PF4 SUPPTS, TF-PRE-LOAD, BASE SUPPORT INTERFACE, ETC.



F. Dahlgren -SC Project Review of NCSX, April 8-10, 2008

