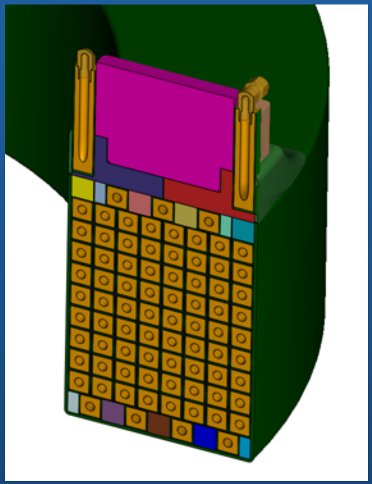
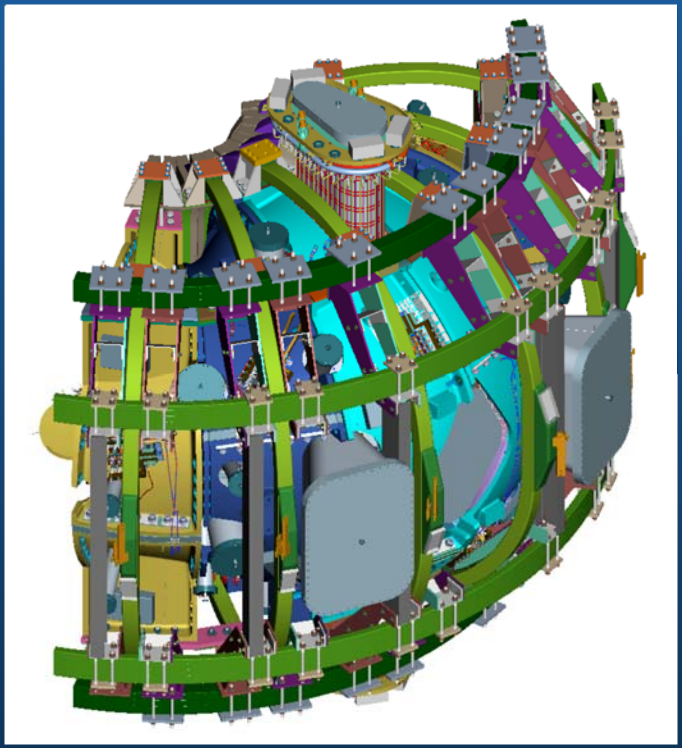
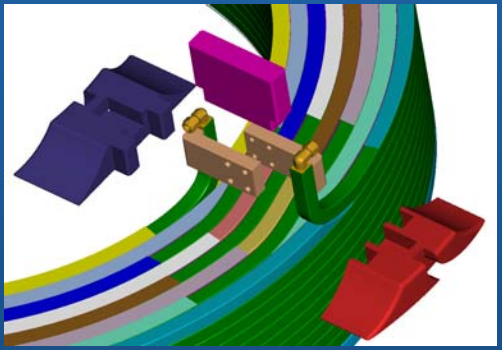
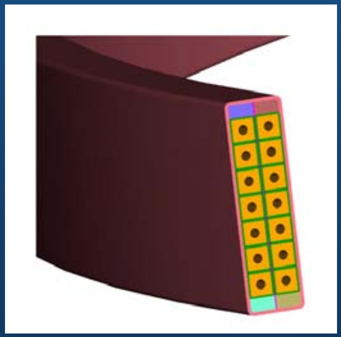
NCSX PF Coil PDR

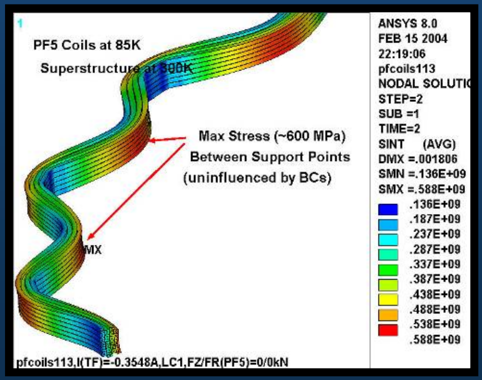
NCSX











Michael Kalish

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Outline

- *Requirements*
- *Design*
- *Analysis and Testing*
- *Procurement Plan, Cost and Schedule*

Requirements

- The PF coils will be designed to meet the requirements of all the reference scenarios. [Ref. GRD Section 3.2.1.5.3.3.2]
  - 1.7 T Ohmic Scenario
  - 1.7 T High Beta Scenario
  - 2 T High Beta Scenario
  - 1.2 T Long Pulse
  - 320 kA Ohmic Scenario
- Electrical
  - Voltage standoff to resist maximum operating voltage of 4KV for PF4
  - Voltage standoff to resist maximum operating voltage of 2KV for PF5 and PF6
  - For PF4 & PF6 Upper and Lower Coils are in series
  - For PF5 Upper and Lower Coils are in Parallel
  - Maintenance Test, Manufacturing Test, and Design Standoff formulas defined

Requirements

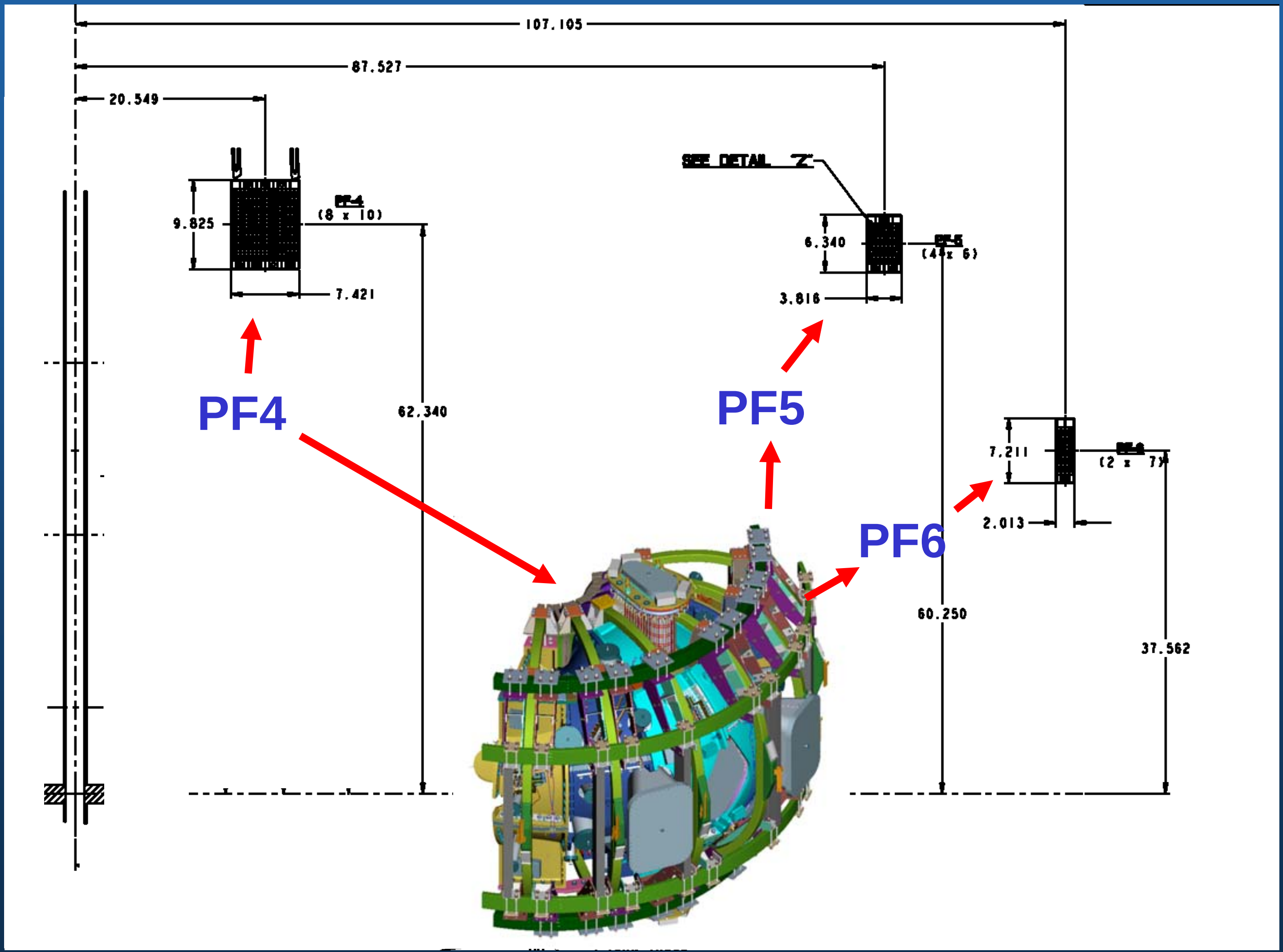
Tolerance / Location

- Global requirement is that toroidal flux in island regions shall not exceed 10%
- In plane installed perturbations less than +/- 3mm
- Out of plane installed perturbations less than +/- 3mm
- Leads and Transitions must have a less than 1% effect on toroidal flux in island regions

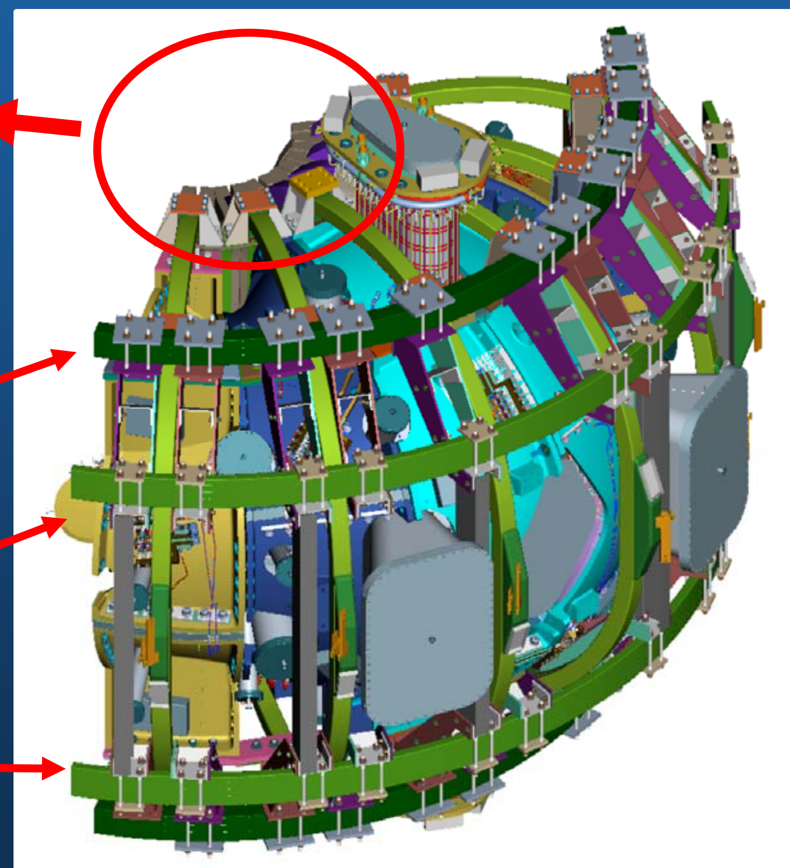
- **Cooling**
  - Pre-Pulse Temp of 80K
  - Pulse repetition rate recovery shall not exceed 15 minutes
- **Design Life**
  - 13,000 cycles per year
  - 130,000 cycles per lifetime

PF Coil Layout

NCSX



PF Coil Layout



PF4 Upper

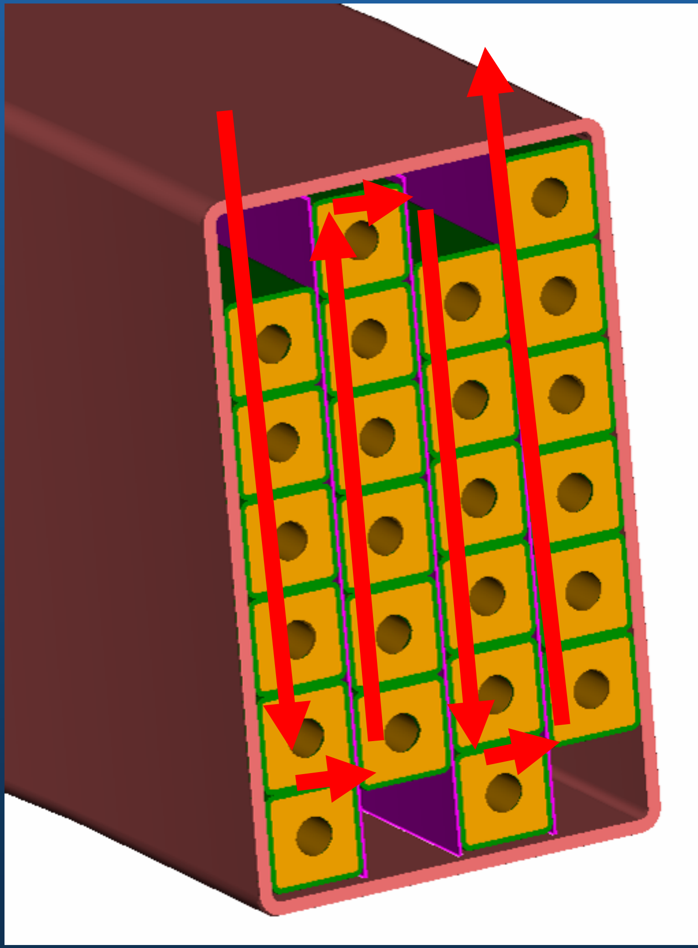
PF5 Upper

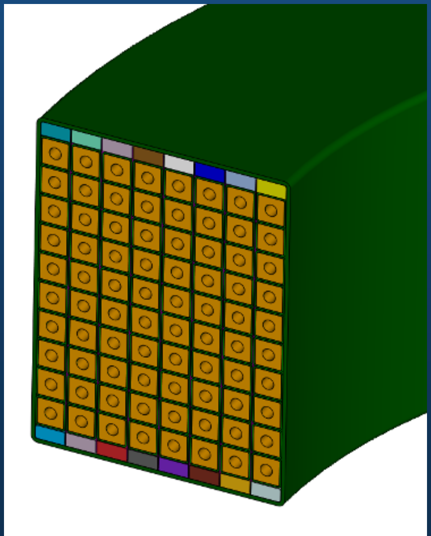
PF6 Upper

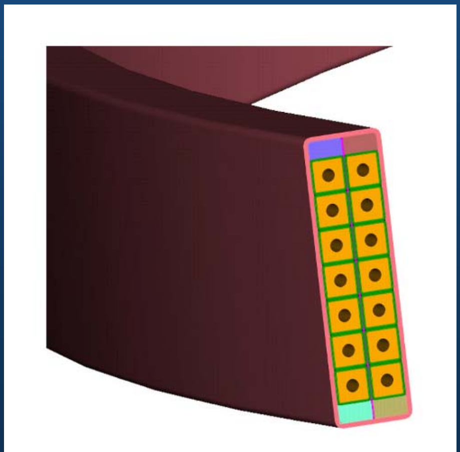
PF6 Lower

PF Coil Cross Section

- PF Coils of conventional design
- Rectangular cross section
- Round Geometry

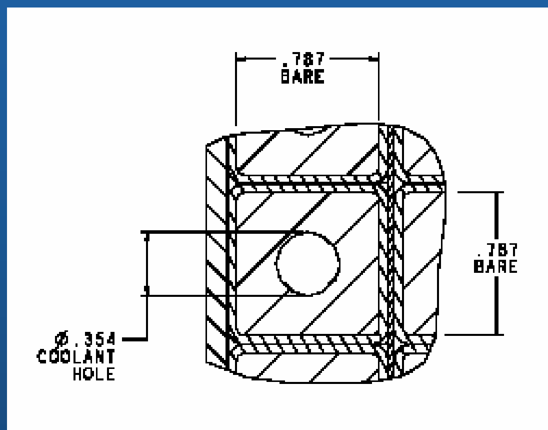


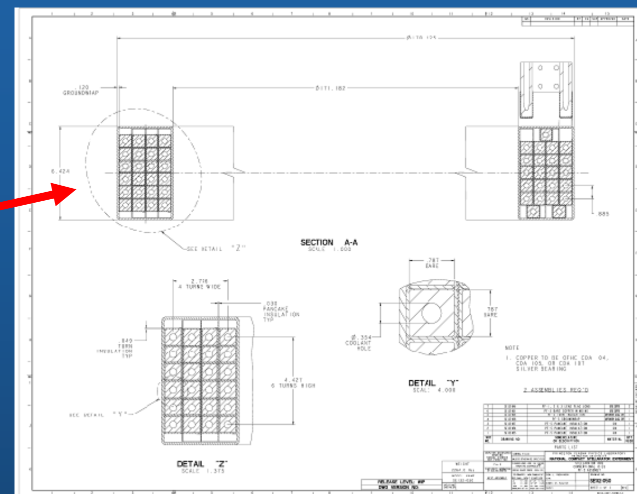


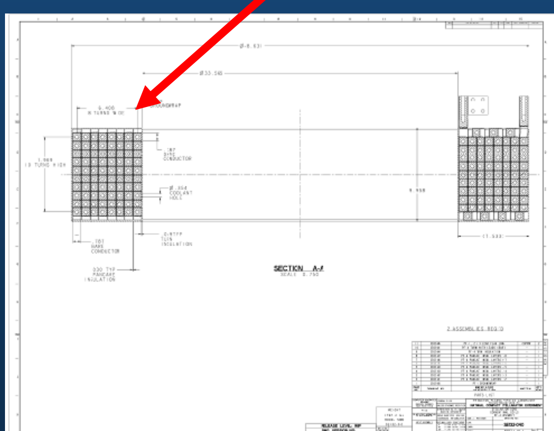


PF Coils, Conductor

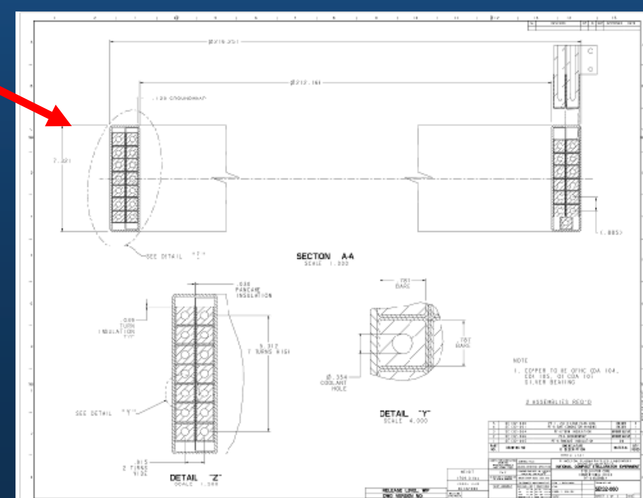
NCSX







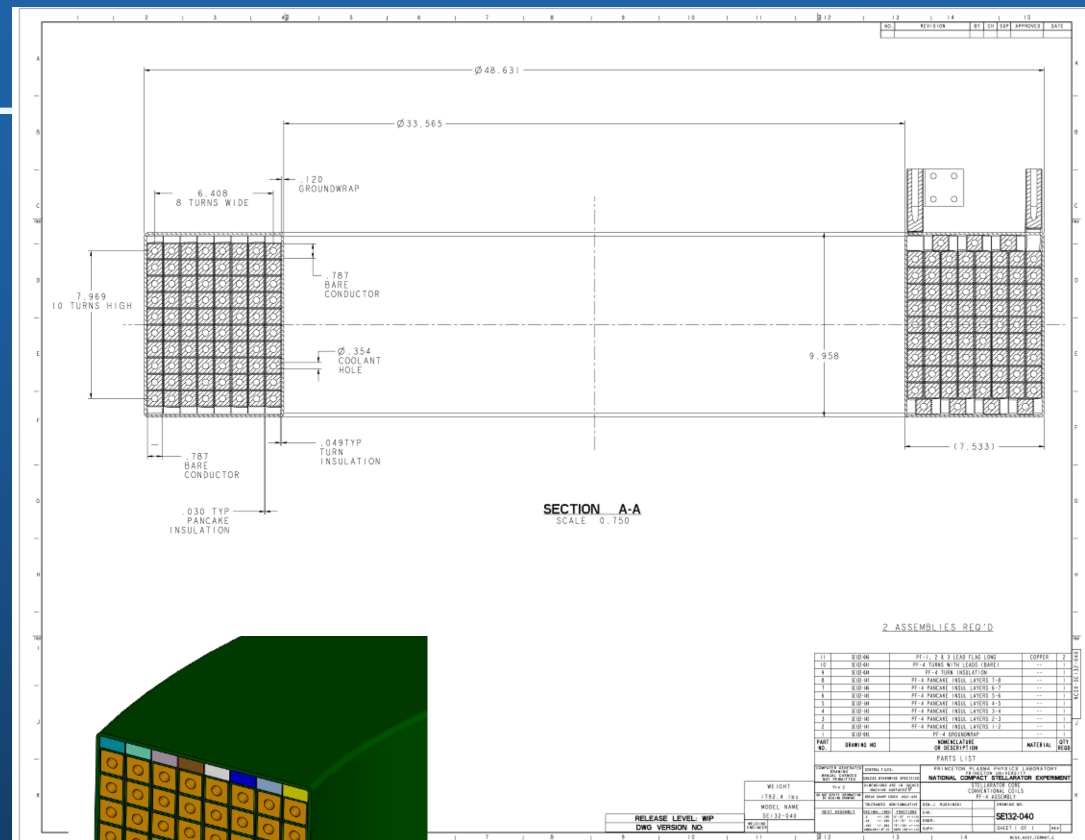
- A single copper conductor size is used for all three different types of PF coils to simplify their manufacture and reduce costs.

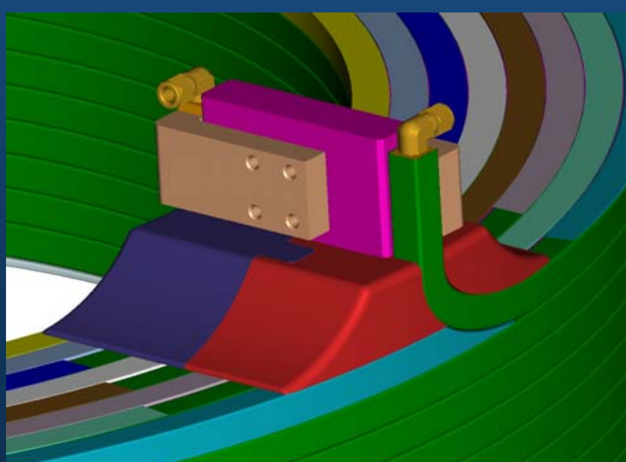


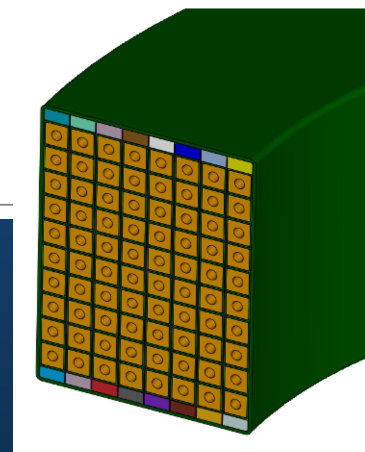
PF4 Geometry

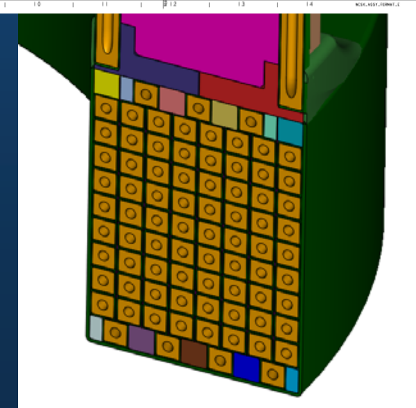
NCSX

- Turns
  = 80
- Outer Diameter
  = 49 inches
- Cross Section
  = 10 x 7.5 inches
- Conductor Length
  = 861 ft





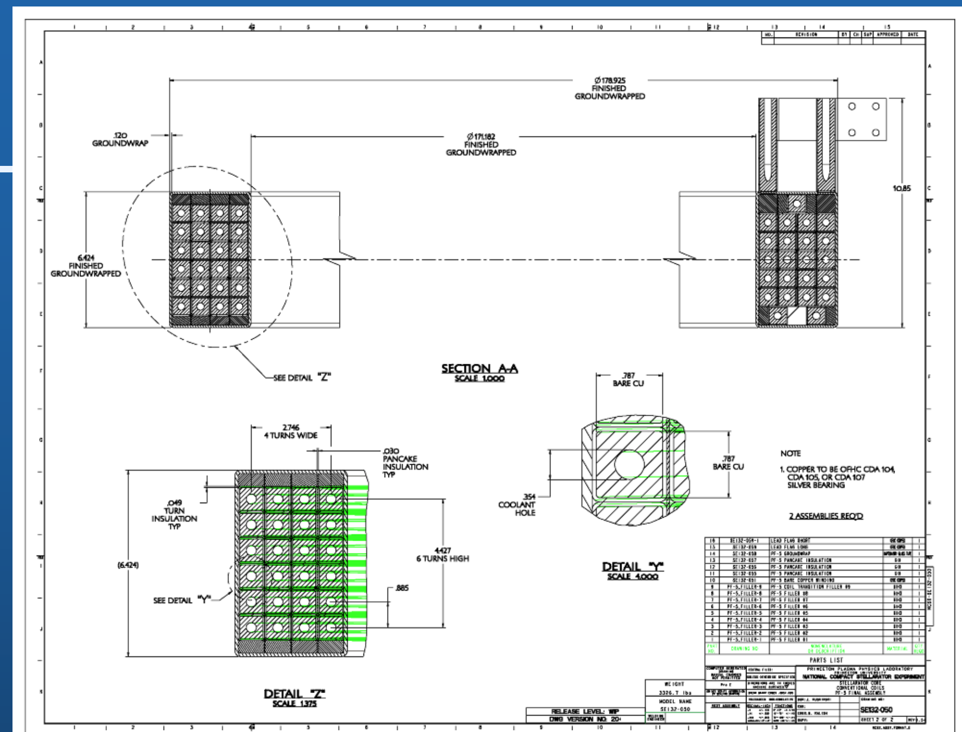


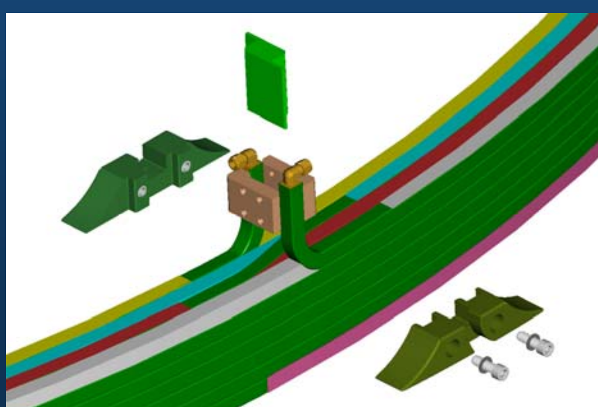


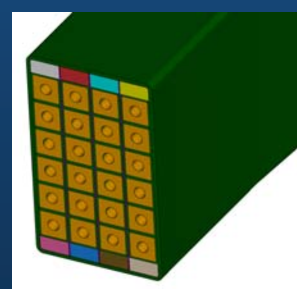
PF5 Geometry

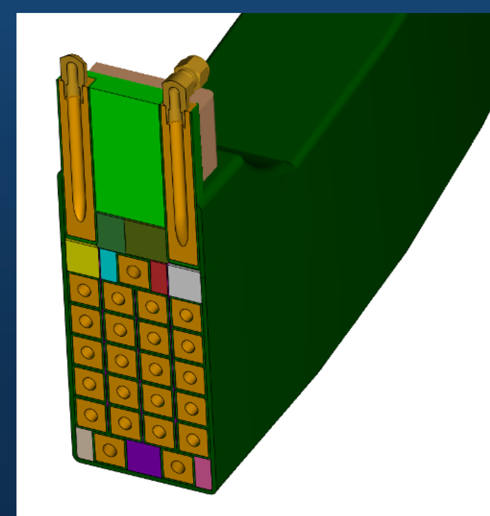
NCSX

- Turns
  = 24
- Outer Diameter
  = 179 inches
- Cross Section
  = 7.7 x 6.4 inches
- Conductor Length
  = 1100 ft





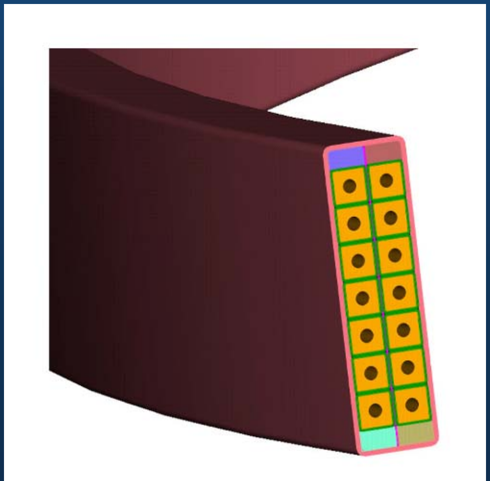


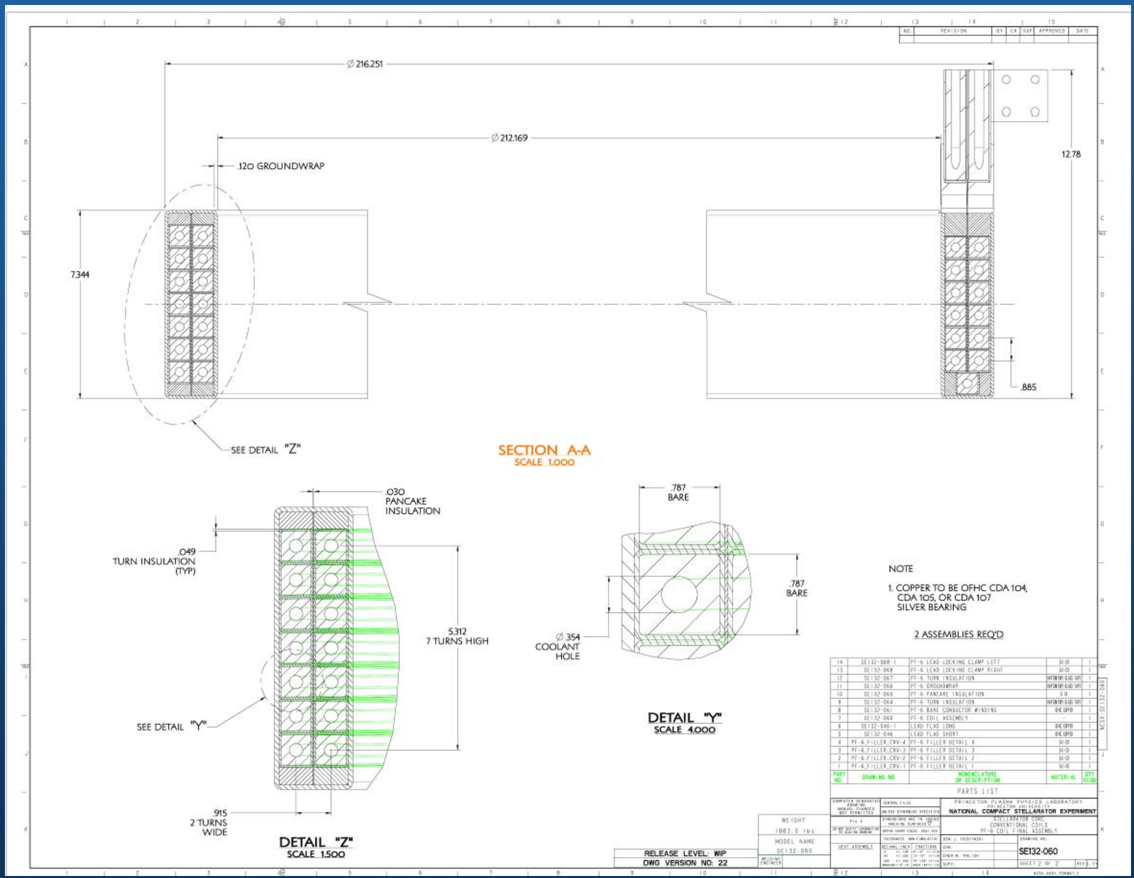


PF6 Geometry

NCSX

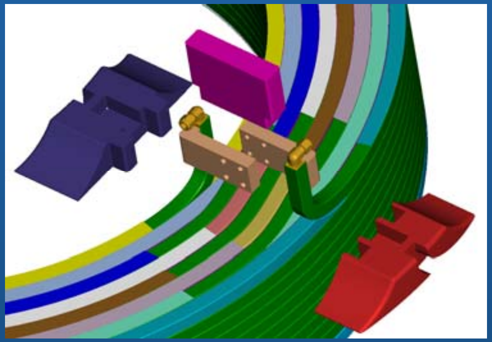
- **Turns**
  = 14
- **Outer Diameter**
  = 216 inches
- **Cross Section**
  = 7.3 x 2.0 inches
- **Conductor Length**
  = 786 ft

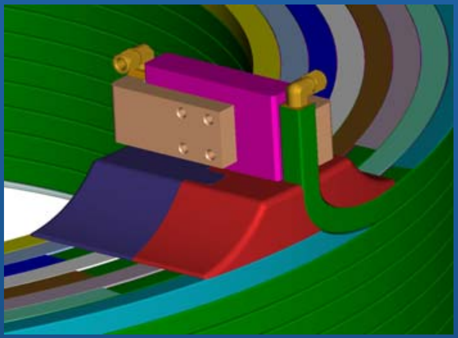


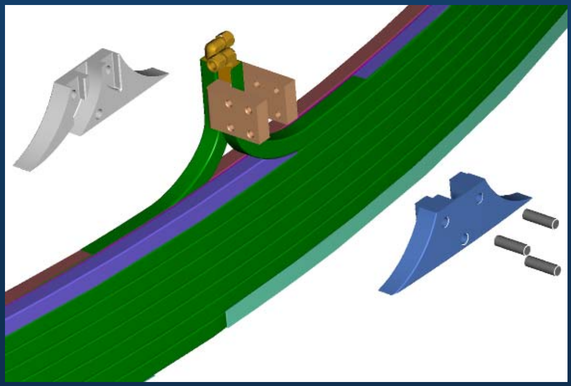


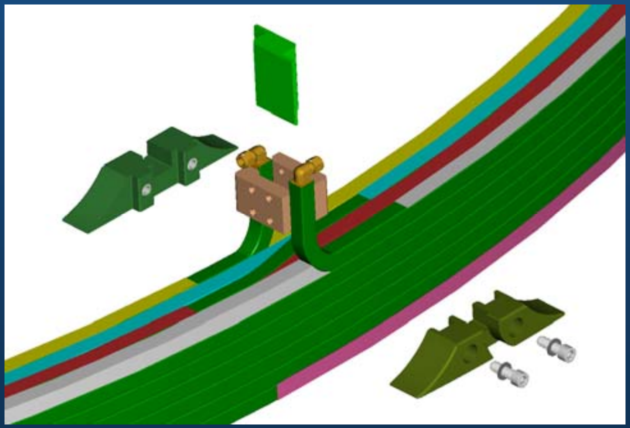
Lead Blocks

- Leads Locked together by G11 Blocks
- Forces on leads very low on the order of 10 lbs excluding exterior fields









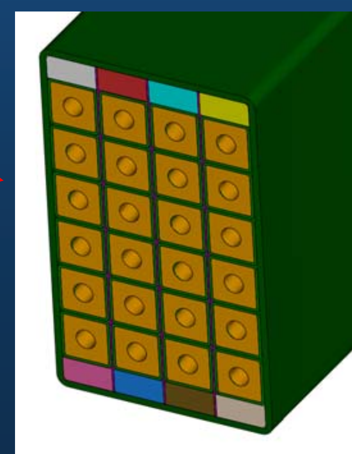
Winding Pack Insulation Design

PF Turn Insulaton					
1/2 Lap Layer Kapton	Kapton	0.002		7.8	
	Adhesive	0.0015			
	Kapton	0.002		0	
	Adhesive	0.0015			
	Glass	0.007		0.63	
	Glass	0.007		0.63	
	Glass	0.007		0.63	
	Glass	0.007		0.63	
	Glass	0.007		0.63	
	Glass	0.007		0.63	
		0.049	**Inches**	**11.58**	**KV**
Ground Wrap PF					
Twenty One 1/2 Lap Layer	Glass	0.009		0.81	
x 21	Glass	0.009		0.81	
		0.375	**Inches**	**33.8**	**KV**

- Kapton Tape applied directly to conductor to enhance turn to turn dielectric standoff and allow for decoupling of insulation from conductor during cool down.

- Generous 3/8" of ground wrap applied to provide "bullet proof" protection to prevent unforeseen potential damage

3/8" of Ground Wrap Insulation



Turn To Turn Voltage Standoff Requirement

- Substantial Margins in Turn to Turn Dielectric Standoff
- Design for 23KV
- Coils nominally see 1KV or less Turn to Turn
- Upper and Lower PF5 not in series raises Turn to Turn standoff requirement

		PF4 Upper &Lower	PF5 Upper	PF5 Lower	PF6 Upper &Lower
Operating Voltage (KV)	per coil for coils in series	2.00	2.00	2.00	2.00
# Of Dielectric Boundaries		4.00	2.00	2.00	1.00
Divide Total Voltage By:	note: = #coils x #Boundaries for all upper and lower coils in series Except for PF5	8.00	2.00	2.00	2.00
Turn to Turn (KV)		0.25	1.00	1.00	1.00
Maintenance Field Test Voltage (KV)	(Operating Volatage x 2) + 1	0.63	2.50	2.50	2.50
Manufacturing Test Voltage (KV)	Maintenance Test Voltage x 1.5	0.94	3.75	3.75	3.75
Design Volatge Standoff (KV)	Manufacturing Test Voltage x 1.5	**1.41**	**5.63**	**5.63**	**5.63**
Turn to Turn Glass Thickness		0.084	0.084	0.084	0.084
Coil Turn to Turn Long Term Break Down (90V/mil)		**23.16**	**23.16**	**23.16**	**23.16**
Coil Turn to Turn per CTD Test		167	167	167	167
Safety Factor (Break Down Voltage / Design Voltage Standoff Requirement)		**16.5**	**4.1**	**4.1**	**4.1**

Ground Plane Voltage Standoff Requirement

- Voltage standoff to resist maximum operating voltage of 4KV
- Maintenance Test, Manufacturing Test, and Design Standoff formulas defined
- Design Voltage Standoff to ground is 45 KV for all three coils
- Ground Wrap dielectric standoff requirement meets system requirement

		PF4	PF5	PF6
Operating Voltage (KV)		2.00	4.00	2.00
Maintenance Field Test Voltage (KV)	(Operating Volatage x 2) + 1	5.00	9.00	5.00
Manufacturing Test Voltage (KV)	Maintenance Test Voltage x 1.5	7.50	13.50	7.50
Design Volatge Standoff (KV)	Manufacturing Test Voltage x 1.5	**11.25**	**20.25**	**11.25**
Turn to Turn Glass Thickness		0.084	0.084	0.084
Coil Turn to Turn Long Term Break Down (90V/mil+Kapton)		11.58	11.58	11.58
Ground Wrap Long Term Break Down		33.8	33.8	33.8
Standoff For Lead Stems KV		**40.9**	**40.9**	**40.9**
Standoff to Ground KV	Ground + Turn Insulation	**45.3**	**45.3**	**45.3**
Safety Factor Lead Stem (Lead Stem Standoff / Design Voltage Standoff Requirement)		**3.6**	**2.0**	**3.6**
Safety Factor to GND (Standoff to Ground / Design Voltage Standoff Requirement)		**4.0**	**2.2**	**4.0**

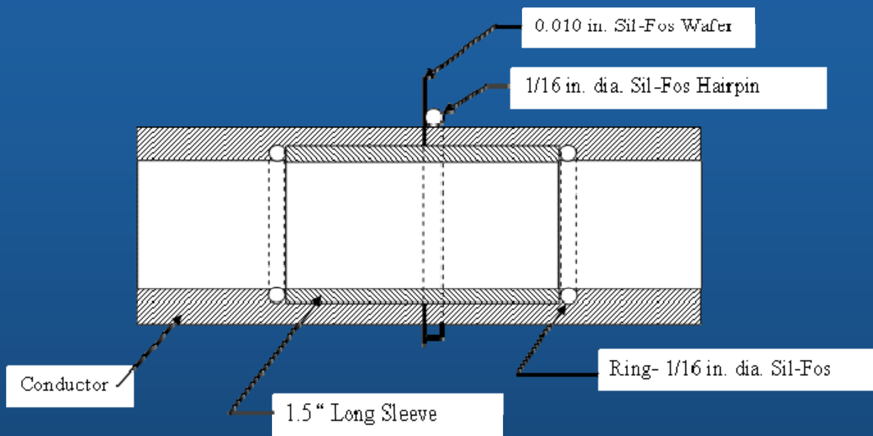
Manufacturability - Manufacturing Tolerances

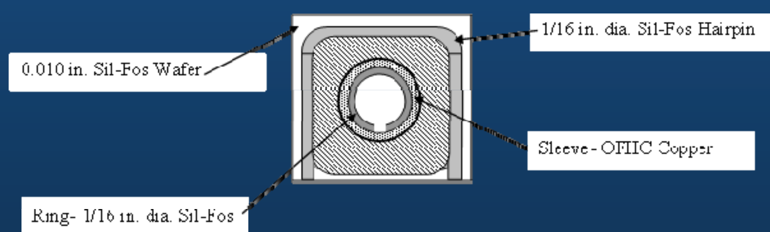
- Requirement = In plane and out of plane installed perturbations shall be less than +/- 3mm
- Coil specification will require +/- 1.5mm using half of the allowable installed tolerance budget
- D Shaped NCSX TF Coils have been manufactured to about a +/- 1.5mm tolerance in their free state but a guarantee of that over the larger diameters for the PF Coils is not guaranteed
- Coil as it is removed from the VPI mold will be within

  +/- 1mm but coil is likely to distort in it's free state
- Support structure must be capable of re-shaping coil as required
- Coils can be positioned during installation to average out of tolerance conditions

Manufacturability- TF Brazed Joint

NCSX





- Example of a Typical Brazed Joint
- Sleeve is used with "Sil-Fos" Wafer and 1.5mm diameter ring. to ensure full coverage and no voids
- Induction brazing strongly recommended but may eliminate potential vendors

Sensor Loop Placement

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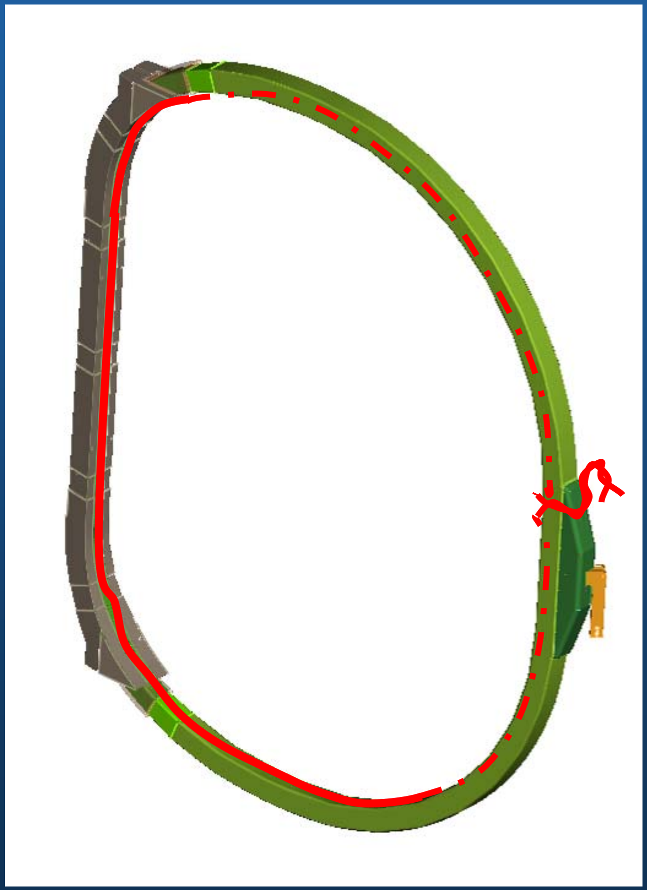
- Sensor Loops will be applied to ID of coil as they are on TF Coils
- Applied under last layer of ground wrap insulation
- Twisted and brought out near leads
- Mounting provisions provided for splice box or strain relief



Outline

- *Requirements*
- *Design*
- *Analysis and Testing*
- *Procurement Plan, Cost and Schedule*

Thermal / Hydraulic Analysis Requirements

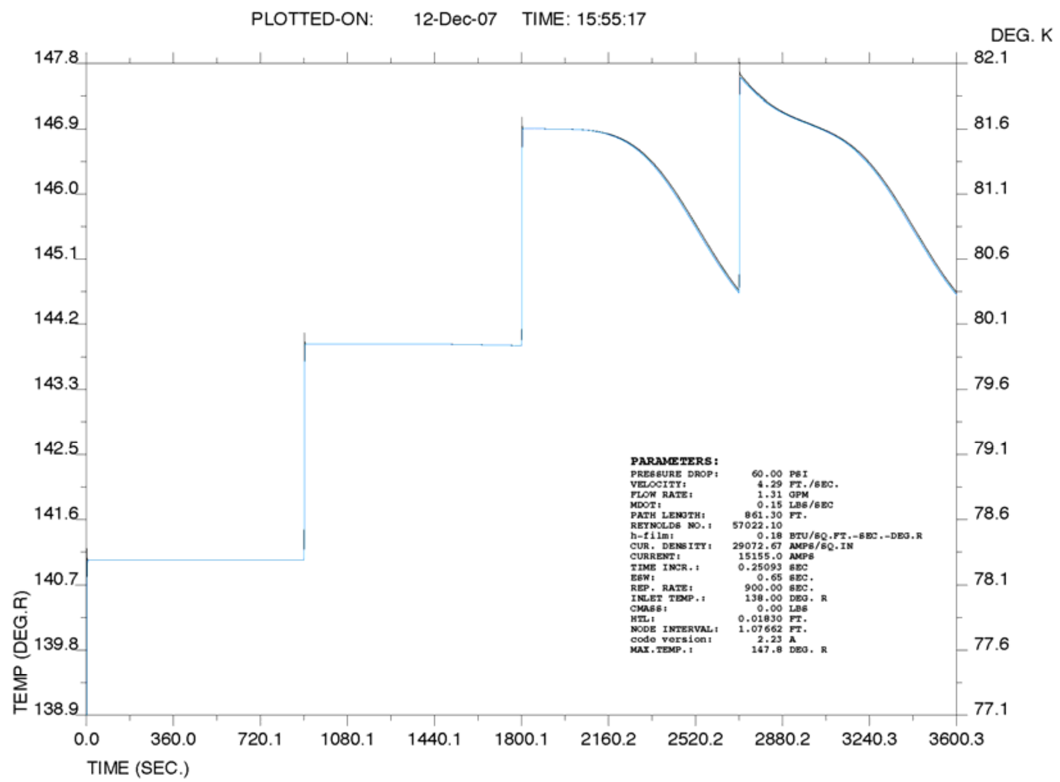
- Peak temperature and recovery time calculated for maximum required pulse (highest I^2T Operating Scenario) for each coil per the GRD
- Pulse Repetition not to exceed 15 minutes

	PF 4	PF5	PF6
Operating Scenario	320 kA Ohmic	1.7T High Beta	1.7T Ohmic
Equivalent Square Wave	.65 Seconds	.54 Seconds	.73 Seconds
Max Current	15155 Amps	7728 Amps	8195 Amps

Thermal / Hydraulic Analysis Results

NCSX

- The pressure differential requirement is 60 psi for PF4 (same as the TF Coils).
- PF4 Peak temperature rise is 5 deg C
- PF4 base temperature increases by 3 deg C and then cycles 2 deg per each 15 minute pulse.
- PF5 and PF6 experience total temperature excursions of less than 2 deg C
- RMS Power is low enough that PF5 and PF6 could rely on convection cooling alone if necessary
- LN2 system Flow requirement is between 1 and 1.2 GPM per coil
- Total flow requirement for all six coils is less than 7 GPM



NCSX PF4 Coil LN2-cooling 15.15kA, 0.65 ESW

Stress Analysis Inputs

NCSX

- Time points analyzed for all scenarios
- Highest Loads not necessarily at maximum currents
- Coils analyzed with fixed and flexible supports
- Coils analyzed with and without thermal stress for worst case (highest force) operating conditions
- Note: Before FDR Analysis requires checking, some current inputs in the GRD have been changed since this analysis

  (I^2T for PF4 +10% & I^2 for PF5 -30%)

Table 2.0-1 Magnetic Forces from Max Current Time Points

Time Point	PF4U [kN] Vertical/Radial	PF5U [kN] Vertical/Radial	PF6U [kN] Vertical/Radial
1.7 T Ohmic, t=0.0 s (PF6 I_{min})	**-222/+725**	**+85/+22**	**-82/+53**
2.0 T High-β, t=0.197 s (PF6 I_{max})	-87/+820	-11/+46	+10/+36
320 kA Ohmic, t=0.206 s (PF4 I_{min})	**-201/+1984**	**-10/+82**	**+18/+19**
1.7 T High-β, t=0.0 s (PF5 I_{max})	-46/+118	+68/+23	-72/+51
Gravity (from 3D ANSYS model)	-9.8/0	-14/0	-9.6/0

Stress Analysis Thermal vs EM Hoop Deflections

- Initial calculation demonstrates thermal deflections due to cool down predominate
- EM Hoop stress and deflection is insignificant
- Analysis indicates overall stresses are low if cool down is homogeneous

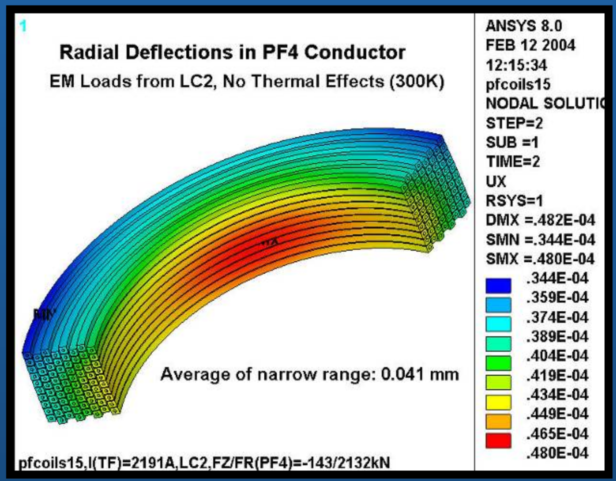
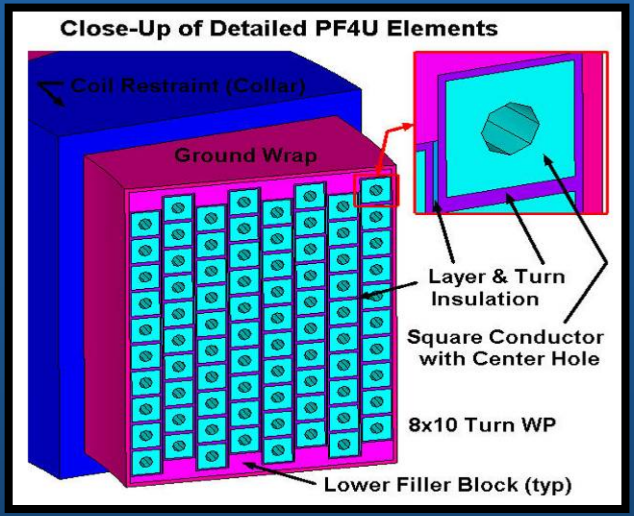
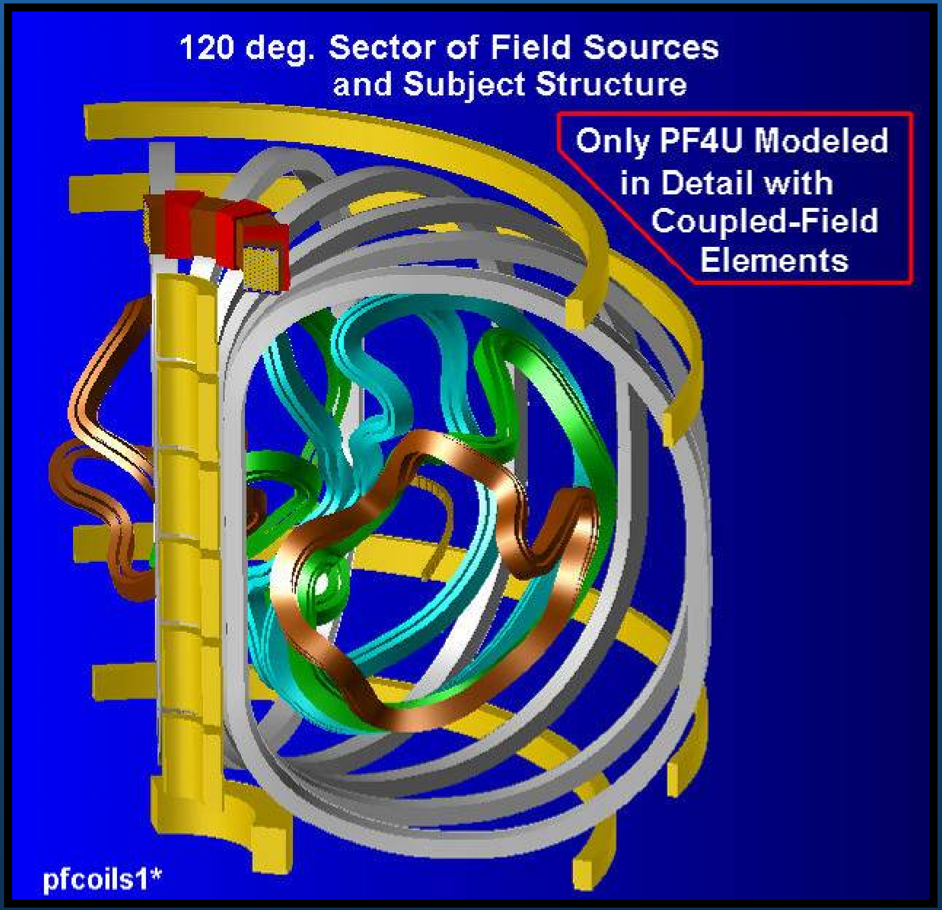


Table 2.0-2 Nominal Coil Hoop Stress and Radial Deflection

PF	Radial Force, F_r [kN]	Coil Dimensions [m]			Ave. Hoop Stress, σ_h $F_r/(2\pi drdz)$ [MPa]	Ave. Hoop Modulus[1] E [GPa]	Deflection [mm]	
		r	dr	dz			Magnetic $(\sigma_h/E)r$	Thermal $(\alpha\Delta T)r$
4	1984	0.522	0.1852	0.2473	7	93	0.04	1.5
5	82	2.223	0.0922	0.1574	1		0.02	6.2
6	53	2.720	0.0457	0.1798	1		0.03	7.6

Stress Analysis Method





- **Model run with coils using smeared properties except for coil of interest which is modeled in detail**

Stress Analysis – Copper

NCSX

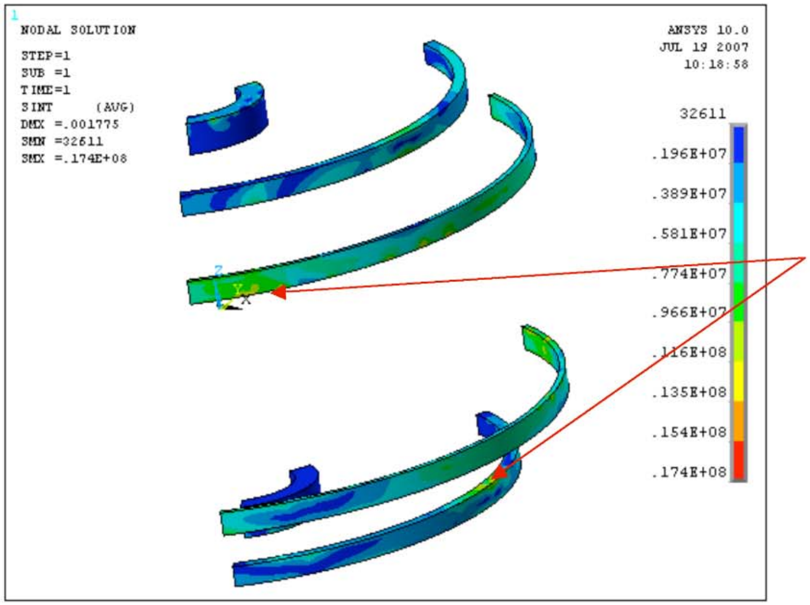
- **Allowable copper stress Sm is 110 MPa**
- **Using a lower (softer) requirement than TF Coil (Sm=180 MPa) could enhance manufacturability of PF Coils**
- **With coils and structure at the same temperature there remains a factor of safety of at least two**
- **Present structure design utilizes a clamped configuration so further analysis is recommended to identify the maximum allowable temperature differential between the structure and the coils**

Run	PF	Radial Constraint	Temp Coil/Structure [K]	LC	Conductor Stress Intensity [MPa]
10	4	free	85/85	0	46.6
15		free	300/300	2	19.2
12		free	85/85	2	49.1
13		clamped	85/85	2	48.0
114		clamped	85/300	0	**731**
16	5	free	85/85	1	49.2
14		free	85/85	2	46.1
19		free	85/85	0	46.1
111		clamped	85/85	0	53.1
113		clamped	85/300	0	**588**
18	6	free	85/85	0	48.1
17		free	85/85	1	51.0
110		clamped	85/85	0	54.6
112		clamped	85/300	0	**744**

Stress Analysis - Copper / Structure PDR Results

NCSX

- Analysis performed for Structure PDR confirms low stresses
- Note that stresses were higher in previous analysis which used a detailed winding pack model

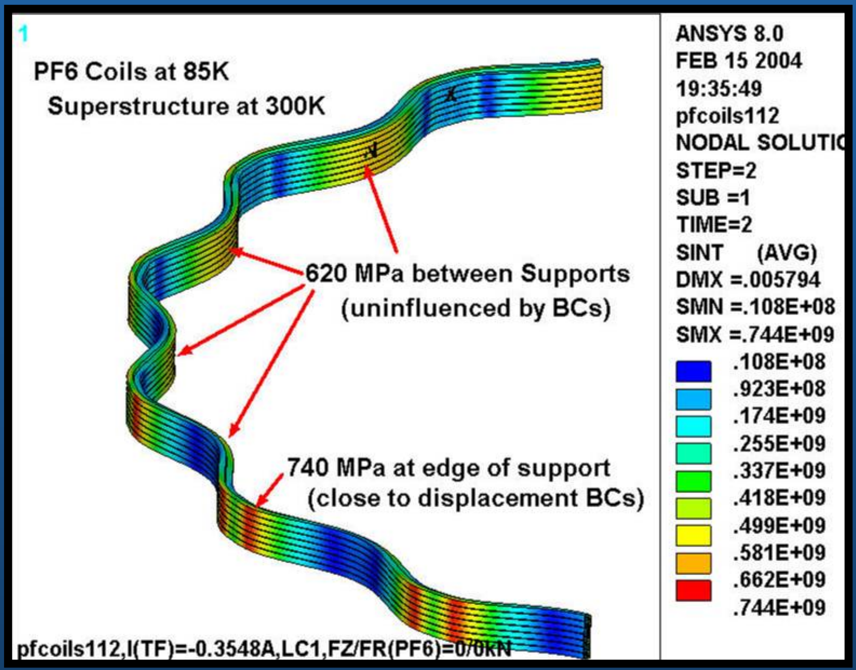


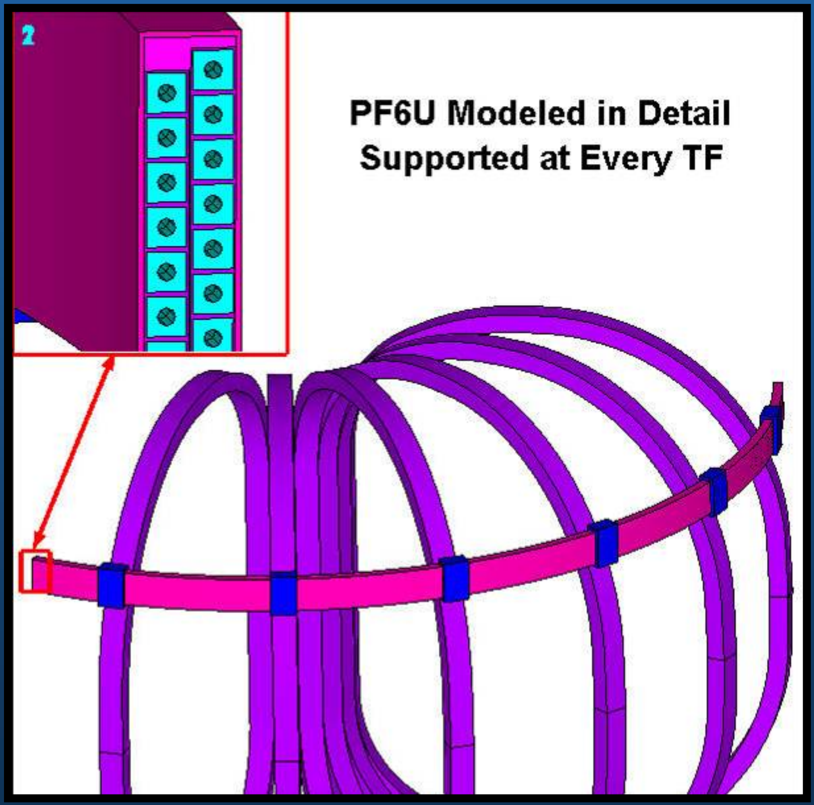
Peak Tresca Stress In the PF coils is only 17.4 Mpa @ the PF5 & 6 support clamps

Results: LC1-1.7T Ohmic EM loads only

Stress Analysis - Copper / Large Thermal Delta

NCSX





- **PF6 Cu Stresses approach 620 MPa midway between coil supports with coil at 85K and coil supports at 300K**
- **PF4 and PF5 stresses as high**
- **Operational control of the cool down process will be critical**

Stress Analysis Insulation - In Plane & Compression

NCSX

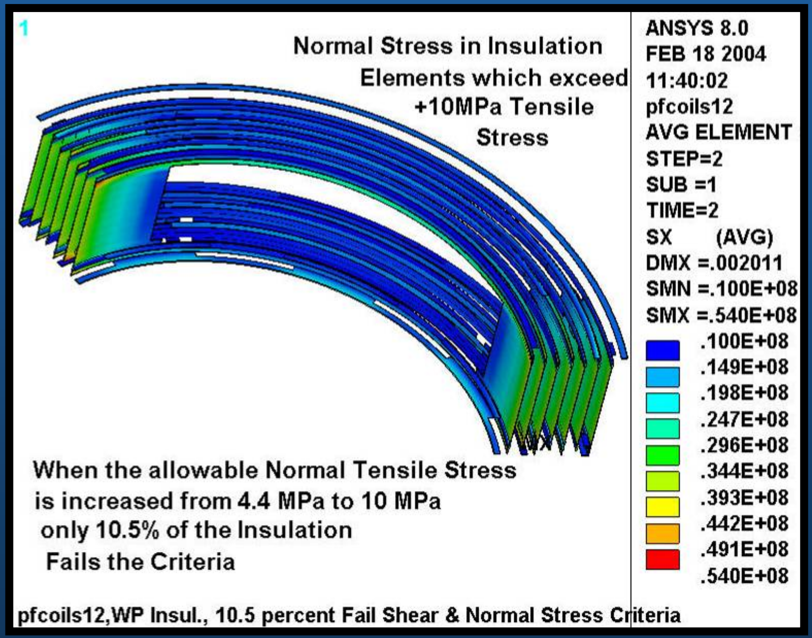
- Stress allowable in plane limited to 165 MPA
- Stress allowable compression limited to 460 MPa
- Insulation Stress "In-Plane" and "Compression" has large margin
- Component of stress due to EM loads is very small

Run	PF	Radial Constraint	Temp Coil/Structure [K]	LC	In-Plane Compression/Tension [MPa]	Flat-Wise Compression [MPa]
10	4	free	85/85	0	-42.9/+9.6	-6.3
15		free	300/300	2	-0.6/+3.4	-3.0
12		free	85/85	2	-42.5/+10.1	-8.3
13		clamped	85/85	2	-41.4/+10.8	-8.3
114		clamped	85/300	0	-93.9/+81.3	-177
16	5	free	85/85	1	-40.9/+10.6	-7.4
14		free	85/85	2	-41.1/+10.4	-7.1
19		free	85/85	0	-40.7/+10.3	-7.1
111		clamped	85/85	0	-39.0/+12.9	-7.2
113		clamped	85/300	0	-49.5/+103	-81.8
18	6	free	85/85	0	-39.6/+10.2	-6.4
17		free	85/85	1	-40.7/+10.5	-6.6
110		clamped	85/85	0	-36.6/+13.0	-7.5
112		clamped	85/300	0	-110/+140	-99.5

Stress Analysis Insulation Tensile

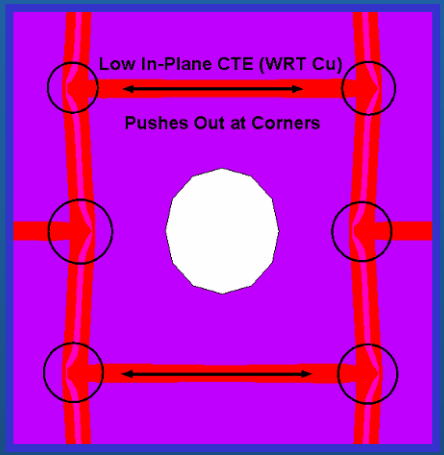
NCSX

- EM loads contribute insignificantly to the tensile insulation stress
- Analysis of local tensile loads indicates failure of the bond to the cooper conductor
- Testing pursued to determine if higher allowable tensile value could be used
- Testing indicates that tensile allowable is between “0” and 4.4 MPa



Stress Analysis Insulation - Testing

- **Analysis showed risk of insulation cracking due to thermal stresses**



- **Original Plan to resolve thermal stress on winding pack issues**
  - Remove Kapton to increase adhesion
  - Test to provide tensile stress allowables
  - Required greater than 10 MPa
- **Results from CTD Testing Yielded Poor Results for Tensile strength / adhesion**

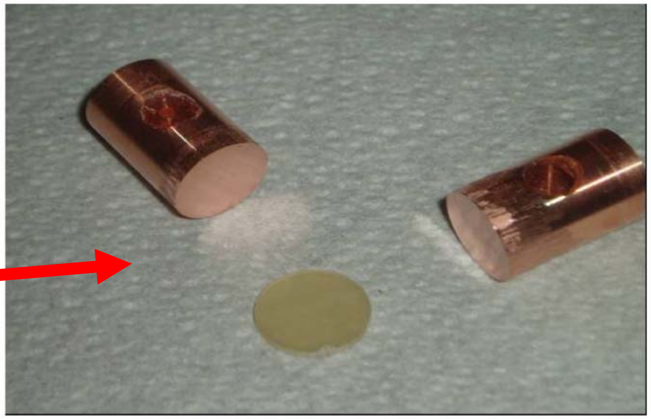
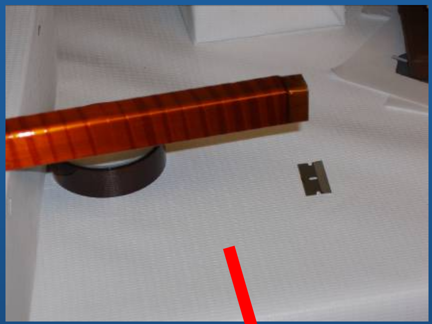


Figure 5. Typical adhesion to metal surface failure.

PDR Winding Pack Insulation Scheme

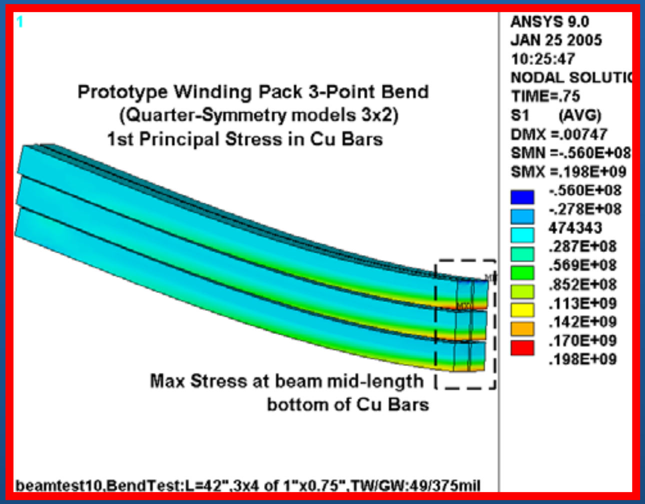
NCSX

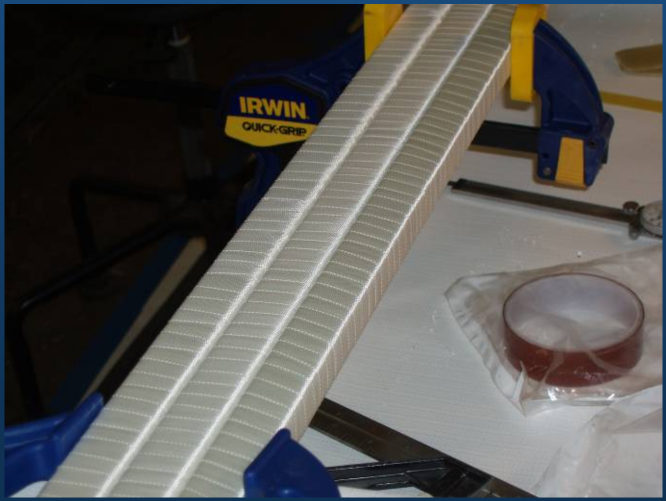
- Original insulation scheme was re-evaluated and evolved to address thermal stress issue
- ½ Lap Layer of Kapton to provide primary dielectric strength
- System to allow loss of adhesion to conductor
- Releasing Kapton layer resolves thermal stress issue.
- Analysis verifies that coil stiffness is adequate after releasing insulation from conductors
- Prototype testing proved out insulation winding pack approach



Prototype Bar Testing

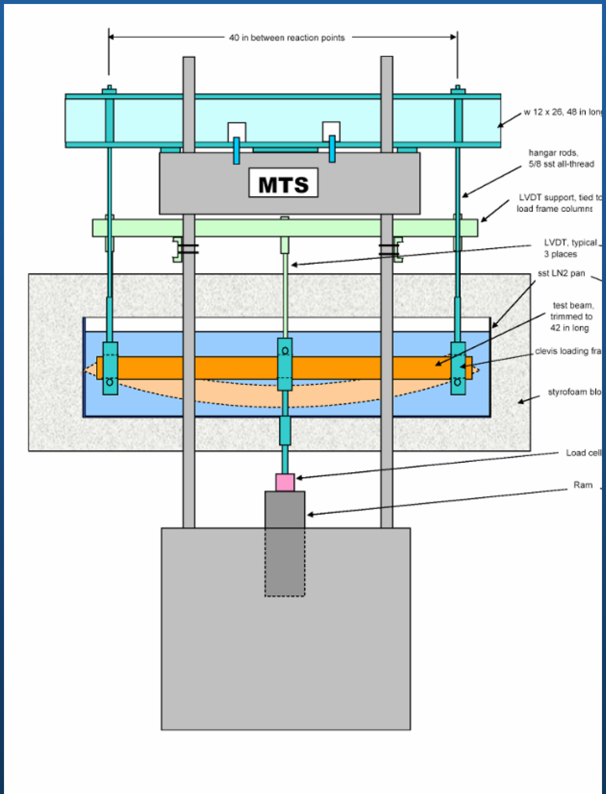
- **Prototype bar underwent both thermal and stress cycling**
- **Proved durability of winding pack design**
  - mechanical properties maintained after more than 2x stress at life
  - successful hipot tests
- **Proved validity of FEA as measured by:**
  - bench mark of mechanical properties to Bar model before and after cycling of prototype
- **While the test bar was not identical to the PF geometry cyclical stresses tested were 5x greater than PF cyclical stresses**
- **Insulation scheme is identical to PF Coils**





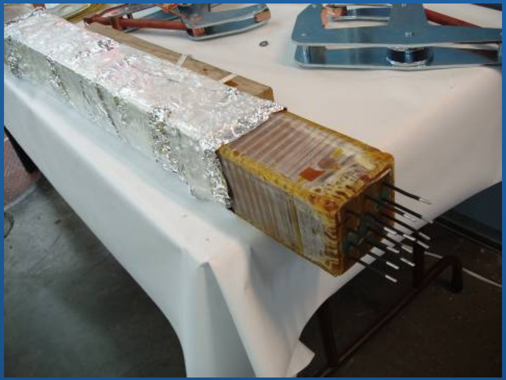
Testing Prototype Bar, Thermal / Fatigue/ Electrical

NCSX



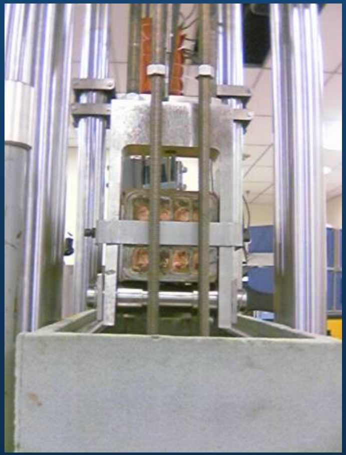
Test Equipment

Sealed Insulation box with test bar Inside

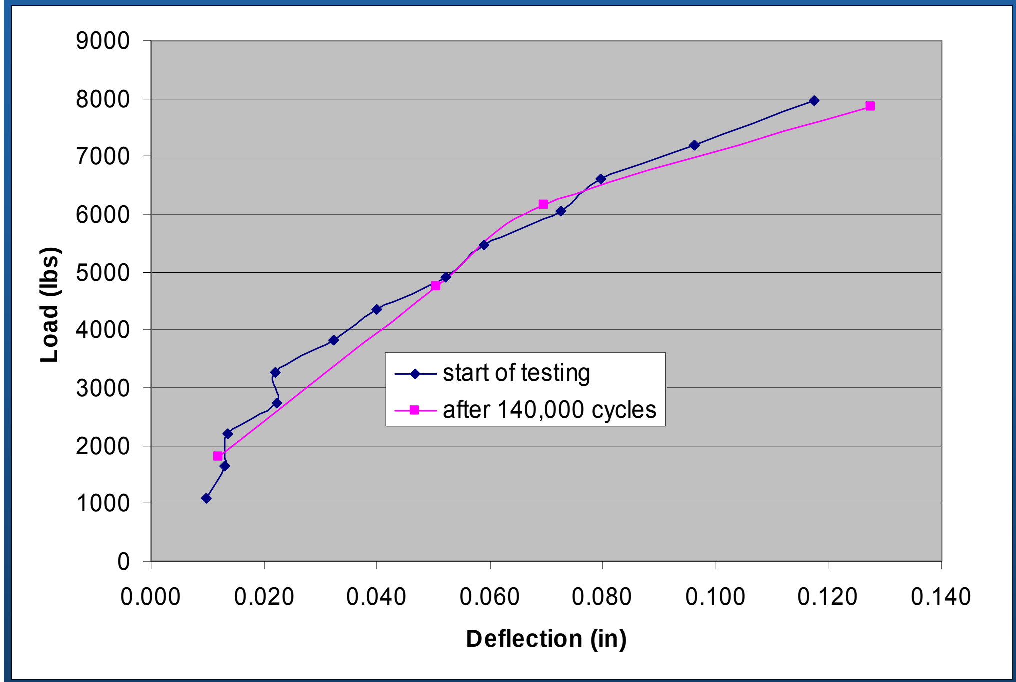


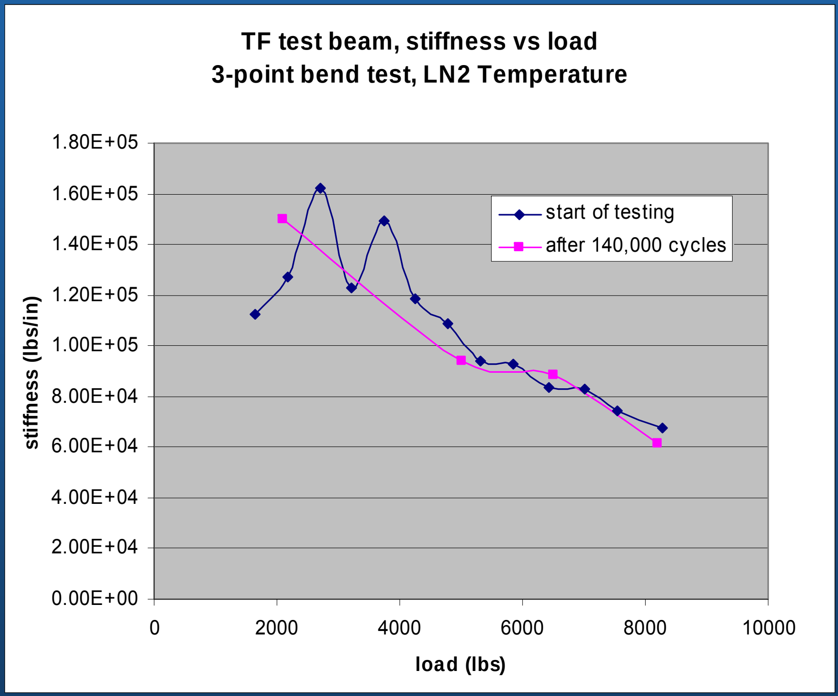
Bar Fitted with Probes for Electrical Testing after Cycling

Test Bar in the fixture with insulation box



Testing TF Winding Pack, Thermal / Fatigue





- **Beam Test Validates Analysis**

  Measured stiffness of beam bracketed by unbonded and bonded insulation analysis

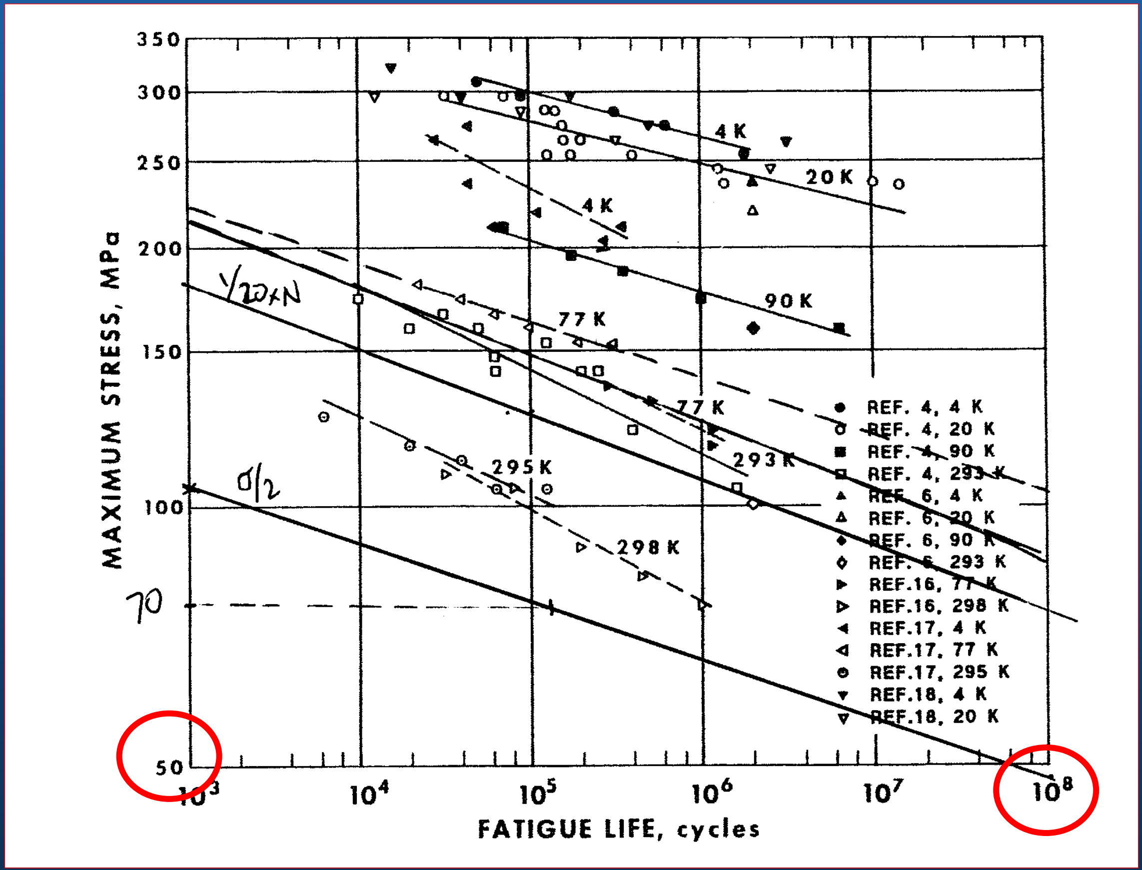
Max Load ≈ 8000 lbs.
Total cycles ≈ 140,000

- **Beam Test Meets Mechanical Criteria for fatigue at > 2x stress at life**

  Stiffness of beam relatively unchanged after 140,000 cycles

Projected Fatigue Life for Conductor

- **Allowable number of cycles (N) based on 20 MPa alternating stress is greater than 100,000,000 (~infinite)**
- **Actual number of required cycles is 130,000**



Fatigue Curve

Analysis and Testing Summary

- Analysis completed for operating scenarios / requirements as specified in the GRD
- Coils meet 15 minute rep rate with a maximum 5 deg C rise
- Conductor meets stress requirements with margin
- Insulation satisfies all relevant stress requirements with margin for in plane and compressive stress
- Cryogenic fatigue tests verify validity of Kapton to conductor insulation scheme at required fatigue life to satisfy tensile stress requirement
- Testing verifies analysis assumptions for composite beam properties
- Testing verifies dielectric standoff for turn to turn and turn to ground requirements

Requirements Addressed

NCSX

- The PF coils will be designed to meet the requirements of all the reference scenarios. [Ref. GRD Section 3.2.1.5.3.3.2]
  - 1.7 T Ohmic Scenario
  - 1.7 T High Beta Scenario
  - 2 T High Beta Scenario
  - 1.2 T Long Pulse
  - 320 kA Ohmic Scenario

  STRESS ANALYSIS OK FOR ALL SCENERIOS
- Electrical
  - Voltage standoff to resist maximum operating voltage of 4KV for PF4
  - Voltage standoff to resist maximum operating voltage of 2KV for PF5 and PF6
  - For PF4 & PF6 Upper and Lower Coils are in series
  - For PF5 Upper and Lower Coils are in Parallel
  - Maintenance Test, Manufacturing Test, and Design Standoff formulas defined

  DEMONSTRATED BY DESIGN AND TEST COILS WILL WITHSTAND THESE REQUIREMENTS

Requirements Addressed

NCSX

- **Tolerance / Location**
  - **Global requirement is that toroidal flux in island regions shall not exceed 10%**
  - **In plane installed perturbations less than +/- 3mm**
  - **Out of plane installed perturbations less than +/- 3mm**
  - **Leads and Transitions must have a less than 1% effect on toroidal flux in island regions**

PROCUREMENT SPECIFICATION WILL ADDRESS TOLERANCES TF COILS BUILT TO SIMILAR TOLERANCES - MAY REQUIRE STRUCTURE TO COMPENSATE

MUST CONFIRM LEAD AREA EFFECT ON FLUX

- **Cooling**
  - **Pre-Pulse Temp of 80K**
  - **Pulse repetition rate recovery shall not to exceed 15 minutes**

ANALYSIS CONFIRMS ACCEPTABLE TEMP. RISE AND REP RATE

- **Design Life**
  - **13,000 cycles per year**
  - **130,000 cycles per lifetime**

TESTING AND ANALYSIS CONFIRMS FATIGUE LIFE

Outline

- ***Requirements***
- ***Design***
- ***Analysis and Testing***
- ***Procurement Plan, Cost and Schedule***

PF Coil Design Schedule

NCSX

99.07X		Retroactive MHX exclusion	22*		01MAY07A	31MAY07A	31MAY07A		100	-38,281.20	-38,281.20	
Job: 1302 - PF Design -KALISH												
FY07 Rebaseline Exercise												
ECP53RBX02		FY07 Rebaseline exercise	22*		01MAY07A	31MAY07A	31MAY07A		100	4,529.98	4,529.98	
1302-200		Complete PF Coil SRD	6		03DEC07*	13DEC07	28AUG07	42	50	2,229.12	4,458.24	EA/EM =24hr ;
1302-205		Update PF Analysis	87*		06AUG07A	07DEC07	24OCT07	41	40	11,537.68	28,844.20	EA//EM =160hr ;
1302-210		Update PF Coil SDD	40		12SEP07A	29JAN08	21DEC07	41	50	2,208.21	4,416.41	EA//EM =24hr ;
1302-211		Complete PF4 PDR Model	97*		30JUL07A	14DEC07	26SEP07	44	90	12,954.87	14,394.30	EA/EM =00hr ; EA/DM =80 ;
1302-212		Complete PF5 PDR Model	91*		07AUG07A	14DEC07	24OCT07	44	90	12,985.26	14,428.07	EA/EM =00hr ; EA/DM =80 ;
1302-213		Complete PF6 PDR Model	91*		07AUG07A	14DEC07	21NOV07	44	90	12,985.26	14,428.07	EA/EM =00hr ; EA/DM =80 ;
1302-251		PDR Level Design Support	91*		07AUG07A	14DEC07	23NOV07	1,196	20	2,164.21	10,821.05	EA/EM =60hr ;
1302-220		Prepare for PDR	8		05DEC07	14DEC07	07DEC07	44		0.00	16,346.88	EA/EM =52hr ; EA/DM =36 ;
1302-225	3	PF Coils - PDR	1	R	14DEC07	14DEC07	11DEC07	44		0.00	2,972.16	EA/EM =16hr ;
1302-240		Disposition PDR Chits	6		17DEC07	02JAN08	17JAN08	44		0.00	4,458.24	CHRZANOWSKI =24hr ;
1302-214		Prepare,Review & Approve conductor spec	16		03JAN08	24JAN08	29JAN08	44		0.00	2,972.16	sv=16hr ;
1302-216		Prepare,Review & Approve coil spec	16		03JAN08	24JAN08	26FEB08	44		0.00	8,916.48	SV =48hr ;
1302-235		Detail Drawings PF4	25		14DEC07	28JAN08	17JAN08	42		0.00	14,860.80	PAUL=80 ;
1302-245		Detail Drawings PF5	25		14DEC07	28JAN08	14FEB08	42		0.00	14,860.80	PAUL =80 ;
1302-260		Detail Drawings PF6	25		14DEC07	28JAN08	13MAR08	42		0.00	14,860.80	PAUL =80 ;
1302-250		Analysis Support	25		14DEC07	28JAN08	13MAR08	42		0.00	13,003.20	KALISH=70hr ;
1302-217		Drawing Support	25		14DEC07	28JAN08	13MAR08	42		0.00	11,145.60	CHRZANOWSKI =60hr ; PAUL =00hr ;
1302-218		PF Stress Analysis with leads	20		17DEC07*	22JAN08	31JAN08	46		0.00	22,291.20	FAN =120hr ; PAUL =00hr ;
1302-265		Prepare for FDR	15		16JAN08*	05FEB08	20MAR08	36		0.00	19,319.04	CHRZANOWSKI =34hr ; PAUL =36 ; SV=34
1302-270	3	PF Coils - FDR	0	R		05FEB08	24MAR08	36		0.00	0.00	
1302-275		Resolve FDR Chits	10		06FEB08	19FEB08	21APR08	154		0.00	14,860.80	CHRZANOWSKI =40hr ; SV=40

Procurement Plan / Issues

NCSX

- Expedite delivery by pre-ordering copper conductor and supplying to vendor / vendors
- Include three coils in one procurement but allow vendors to bid on subsets (Likely that more vendors will bid on smaller PF4 Coil)
- A preliminary information package has been posted to solicit bids on the Federal Business Opportunities web site and the PPPL web site
- A list of potential bidders is compiled
- Everson-Tesla Inc. has indicated strong interest in building PF coils
- Schedule and Cost estimates are based on budgetary information received from Everson as well as PPPL derived estimates
- Critical need dates driven by the installation of the lower PF5 and PF6 Coils. Vendors will be asked to stage deliveries so that these coils are received first.
- Begin early start of procurement by forming SPEB prior to FDR

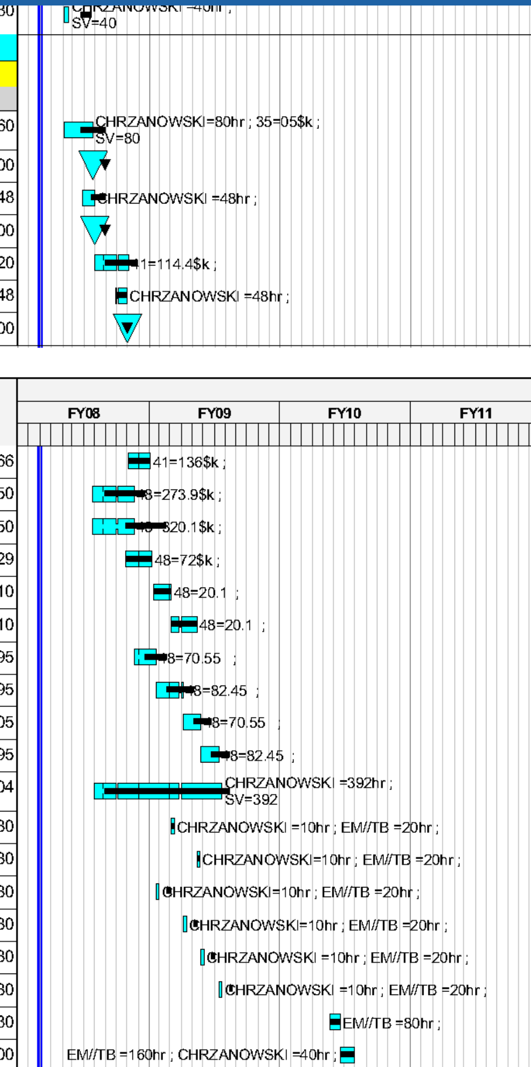
Near Term Procurement Schedule

NCSX

Task #	Description	Duration	Planned Start	Planned Finish	Actual Start	Actual Finish
1.	Issue Sources Sought FedBizOpps Notice		12/11/07	12/11/07		12/11/07
2.	Receive Statements of Interest		12/11/07	1/04/08[1]		
3.	Requisition issued		1/09/08	1/09/08		
4.	SPEB Appointed		1/11/08	1/11/08		
5.	Source Selection Plan drafted	3 days	1/15/08	1/17/08		
6.	PF Coil FDR			2/05/08		
7.	Specification/Drawings Finalized	14 days	2/06/08	2/19/08		
8.	RFP issued	2 days	2/20/08	2/21/08		
9.	Pre-Proposal Conference			2/28/08		
10.	Proposals due	32 days	2/22/08	3/24/08		
11.	Proposal Evaluation Completed	14 days	3/25/08	4/08/08		
12.	SPEB Recommendation Completed	3 days	4/09/08	4/11/08		
13.	SSO Decision	5 days	4/12/08	4/16/08		
14.	Subcontract Negotiation	7 days	4/17/08	4/23/08		
15.	Subcontract Awarded	2 days	4/24/08	4/25/08		
16.	Delivery of Lower PF Coil #4, #5 and #6	222 days	4/25/08	12/02/08		
17.	Delivery of Upper PF Coil #5, #5, and #6	393 days	4/25/08	5/22/09		

PF Coil Fabrication Schedule

Activity ID	MILE	Activity Description	Duration (work days	Shifts	Forecast Start	Forecast Finish	Baseline Finish	Total Float	%	Earned value cost (BCWP)	Budget
1302-275		Resolve FDR Chits	10		06FEB08	19FEB08	21APR08	154		0.00	14,860.80
Job: 1352 - PF Coil Procurement-KALISH											
PF Coil Fabrication											
141-035		Bid & Award PF Coil Fabrication	58		06FEB08	25APR08	27MAY08	36		0.00	35,811.60
141-036	2	PF Coils Awarded	0			25APR08	27MAY08	36		0.00	0.00
141-037		Bid & Award Conductor	25		28MAR08	01MAY08	27MAY08	102		0.00	8,916.48
141-038	3	PF Conductor Awarded	0			01MAY08*	27MAY08*	102		0.00	0.00
141-038.1		PF Conductor Delivery	65		02MAY08	04AUG08	27AUG08	102		0.00	149,635.20
141-039		Bid & Award Materials	25		27JUN08	01AUG08	01AUG08	58		0.00	8,916.48
141-040		PF Materials Awarded	0			01AUG08*	01AUG08*	58		0.00	0.00
1352-100		Materials Delivery PF 4,5,6	45		04AUG08	06OCT08	06OCT08	58		0.00	178,529.66
1352-121		Design/Fab Tooling for PF 5	80		28APR08	19AUG08	18SEP08	36		0.00	280,747.50
1352-122		Design/Fab Tooling for PF 6	80		28APR08	19AUG08	17NOV08	81		0.00	328,102.50
1352-120		Tooling for PF 4	55		25JUL08*	10OCT08	10OCT08	54		0.00	74,072.29
1352-150		Fabricate/Dlvr PF 4 lower	35		13OCT08	02DEC08	02DEC08	54		0.00	21,125.10
1352-151		Fabricate/Dlvr PF 4 upper	45		03DEC08	12FEB09	12FEB09	405		0.00	21,125.10
1352-165		Fabricate/Dlvr PF 5 Lower	45		20AUG08	22OCT08	20NOV08	36		0.00	72,965.95
1352-145		Fabricate/Dlvr PF 6 Lower	45		23OCT08	06JAN09	04FEB09	36		0.00	86,654.95
1352-166		Fabricate/Dlvr PF 5 Upper	35		07JAN09	24FEB09	25MAR09	362		0.00	74,148.05
1352-146		Fabricate/Dlvr PF 6 Upper	35		25FEB09	14APR09	13MAY09	362		0.00	86,654.95
141-031		Title III engr WBS 132	241		02MAY08	21APR09	14MAY09	863	LOE	0.00	148,047.04
141-900		PF4 Lower Inspection & Test	5		03DEC08	09DEC08	09DEC08	54		0.00	3,561.30
141-900A		PF4 Upper Inspection & Test	5		13FEB09	19FEB09	19FEB09	405		0.00	3,561.30
141-901		PF5 Lower Inspection & Test	5		23OCT08	29OCT08	01DEC08	81		0.00	3,561.30
141-902		PF6 Lower Inspection & Test	5		07JAN09	13JAN09	11FEB09	36		0.00	3,561.30
141-905		PF5 Upper Inspection & Test	5		25FEB09	03MAR09	01APR09	397		0.00	3,561.30
141-906		PF6 Upper Inspection & Test	5		15APR09	21APR09	20MAY09	362		0.00	3,561.30
141-903		Refurbish PF 1a	20		18FEB10*	17MAR10	17MAR10	101		0.00	6,820.80
141-904		Assemble PF1a and CS structure	30		18MAR10	28APR10	28APR10	101		0.00	21,550.00



PF Coil Baseline Cost Estimate

- Current Baseline Cost Estimate Remains Unchanged
- Estimate driven by vendor budgetary estimates
- Large PF5 and PF6 Coils driven by fixture cost
- Alternate cost saving fixtures identified but initial more expensive approach (+$300K) used to generate baseline estimate
- Baseline materials estimate generated based on insulation and copper conductor cost as of May 07
- Copper prices dropped 15% (about $17K) since estimate
- Alternative in house fabrication estimate did not compare favorably to vendor estimates
- Baseline estimate includes $$$ to by enough copper for one spare coil of any type to reduce risk

Issues Leading To FDR

- Resolve Support Structure Differential Temperature Operational Restrictions
- Initiate Conductor Procurement
- Finalize Details of Lead Area
- Finalize / confirm lead area field perturbation analysis
- Check Calculations
- Complete Detailed Drawings
- Complete Specifications

Charge to Committee

- Verify that all requirements are being addressed. Identify requirements or design conflicts and potential "show stoppers".
- Review the results of analyses, calculations, and tests conducted to obtain additional information for the design
- Review the ability to implement the proposed design taking into consideration capabilities, tolerances, costs, quality, reliability, and ES&H security.
- Review procurement issues, e.g. build vs. buy.
- Review test requirements and plans.
- Review updated design and development plans and schedules.
- Assure the appropriate incorporation of recommendations from previous design reviews.
- Review manufacturability.