

NSCX Conventional Coils

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Outline



- Requirements
- Interfaces
- Design and Fabrication Status
- Cost and schedule estimates
- Risks and mitigation

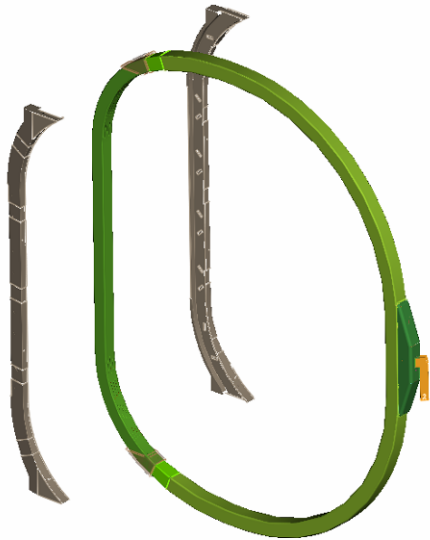
Requirements

- GRD requirements for the operating scenarios drive the analysis which provides physical requirements to the coils
- TF, PF and Trim coils must withstand EM and thermal loads generated by the operating scenarios
- Analysis must demonstrate compliance with thermal, stress, and fatigue criteria
- Trim coils must maintain an island size of less than 10% of total flux for operating scenarios
- Individual requirements for TF, PF and Trim coils are documented in their respective SRDs (system requirements documents)

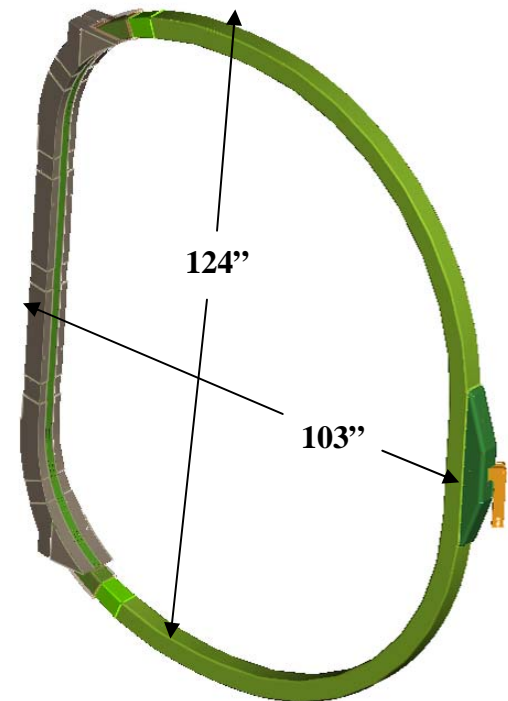
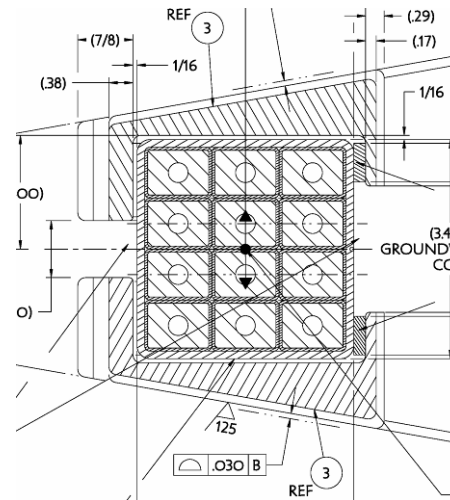
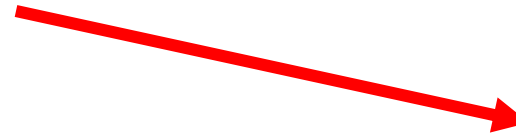
Interfaces

- Interface requirements are defined in the System Requirement Documents for TF, PF, and Trim Coils
- Interfaces included bus connections, liquid nitrogen requirements, and physical interfaces with adjacent hardware
- A magnetics model of the magnet systems determines EM loads and stresses
- The Pro-E model provides the means for integrating all parts and finding interferences

Design - TF Coil Assembly



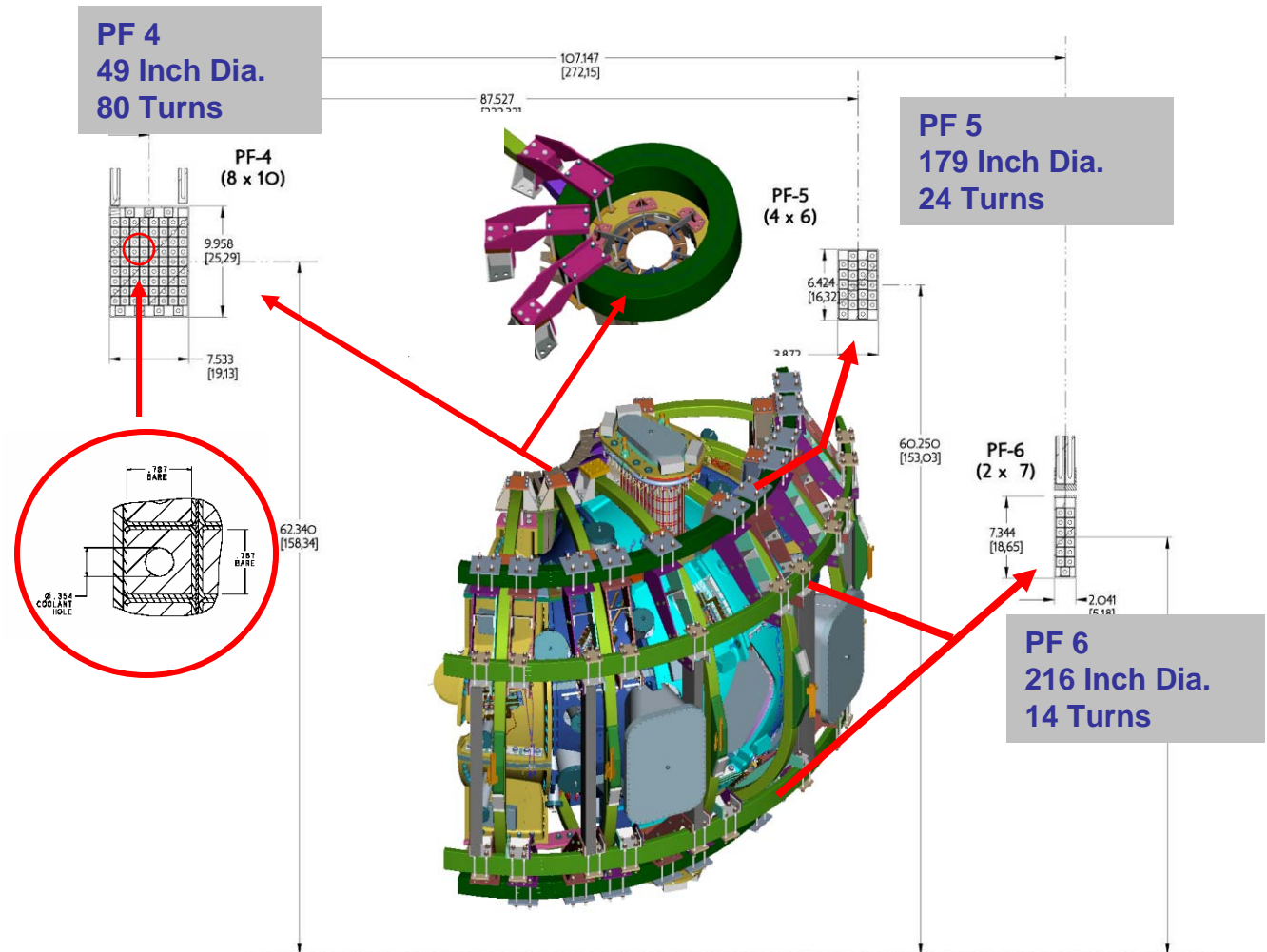
Coil Winding +
Wedge Supports =
TF Coil Subassembly



- Total of 18 TF Coils
- SS Wedges with conventional rectangular cross section coil
- Solid Copper Conductor LN2 Cooled
- VPI with CTD 101K Epoxy

Design - PF Coils

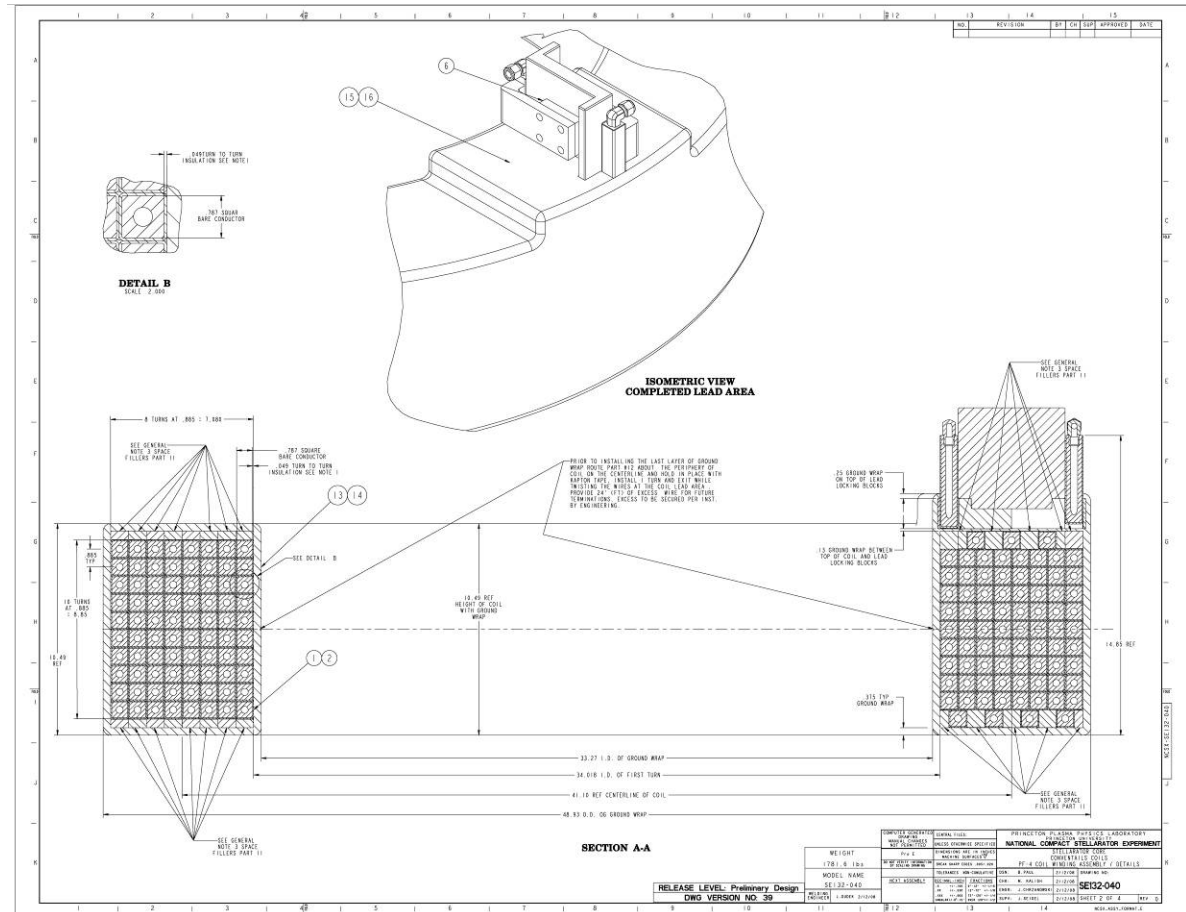
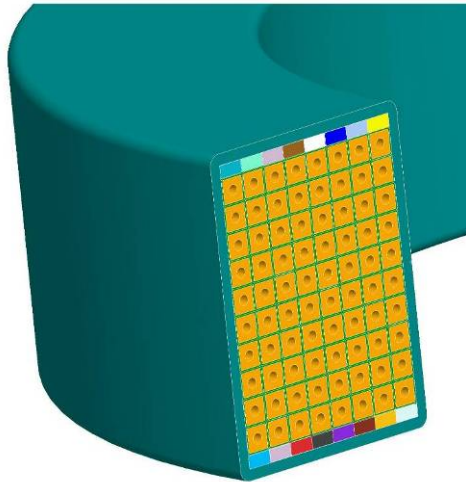
- Two of each PF coil type
- Symmetric round coil geometry
- LN2 cooled solid copper conductor
- Same conductor used for 3 coil types
- VPI Construction
- No SS steel coil case as in TF's



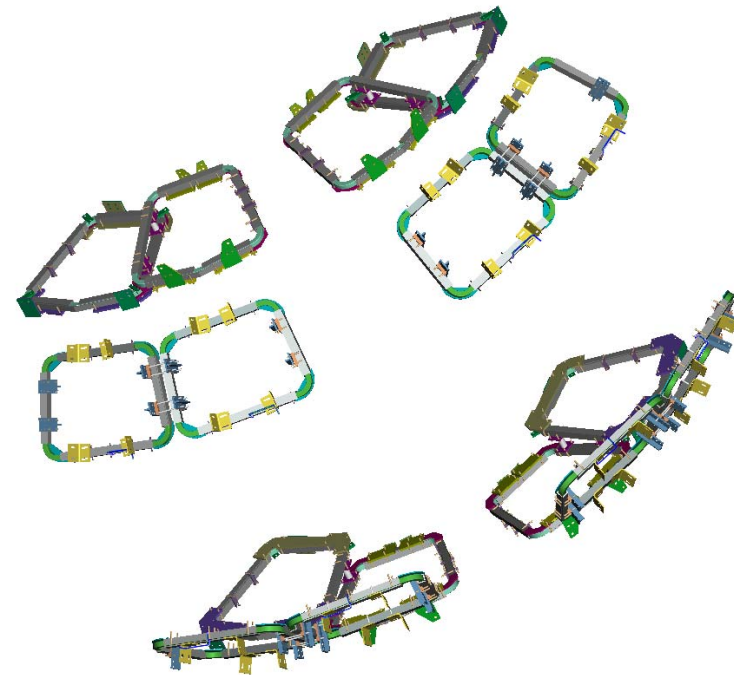
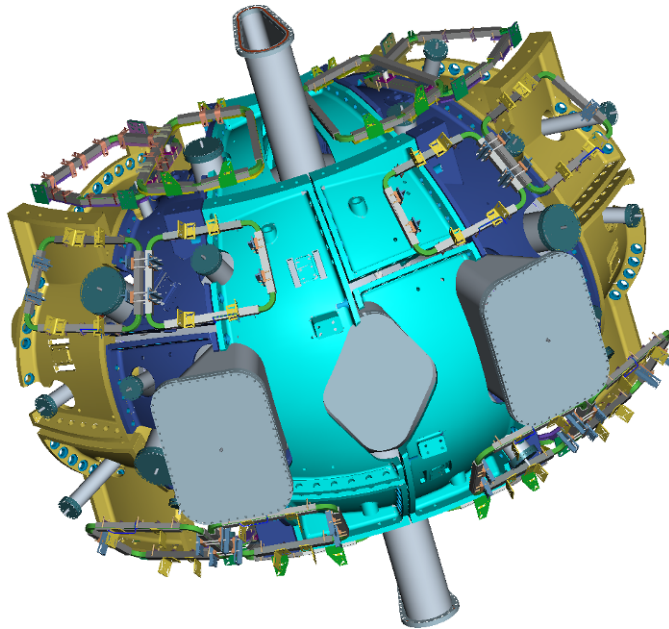
Design - PF Coils



- Final Design Complete
- System Requirements documents generated for coils
- Detailed Procurement specifications and drawings are key to obtaining quality from vendors



Design - Trim Coils

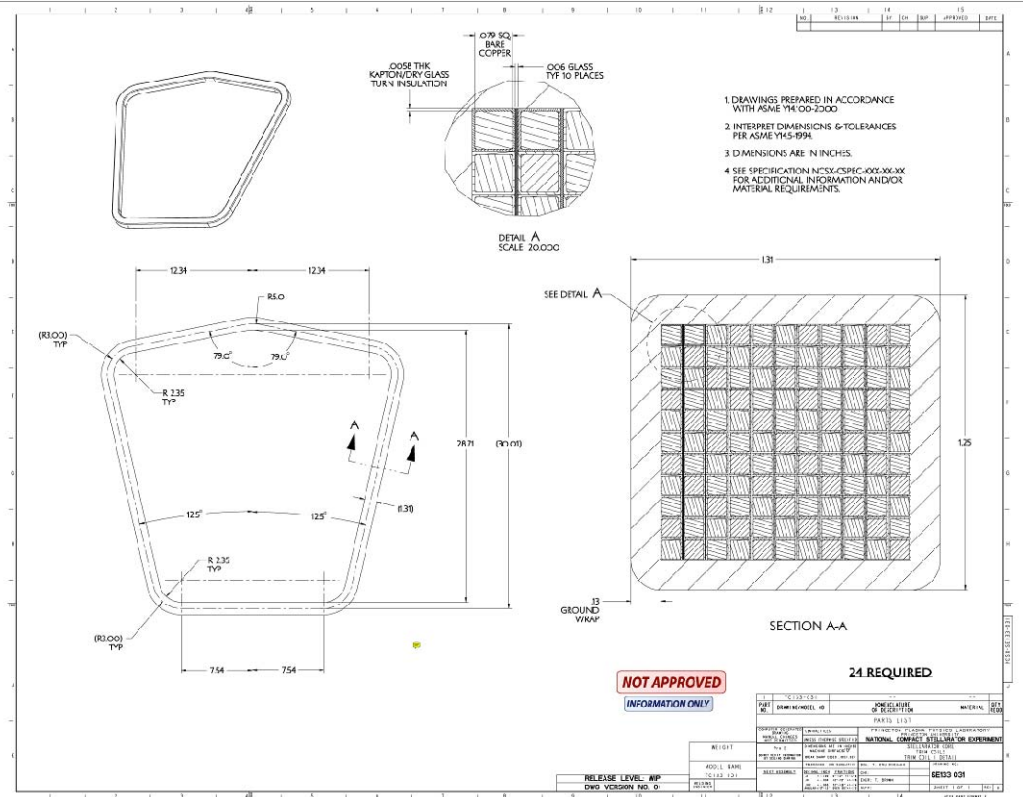
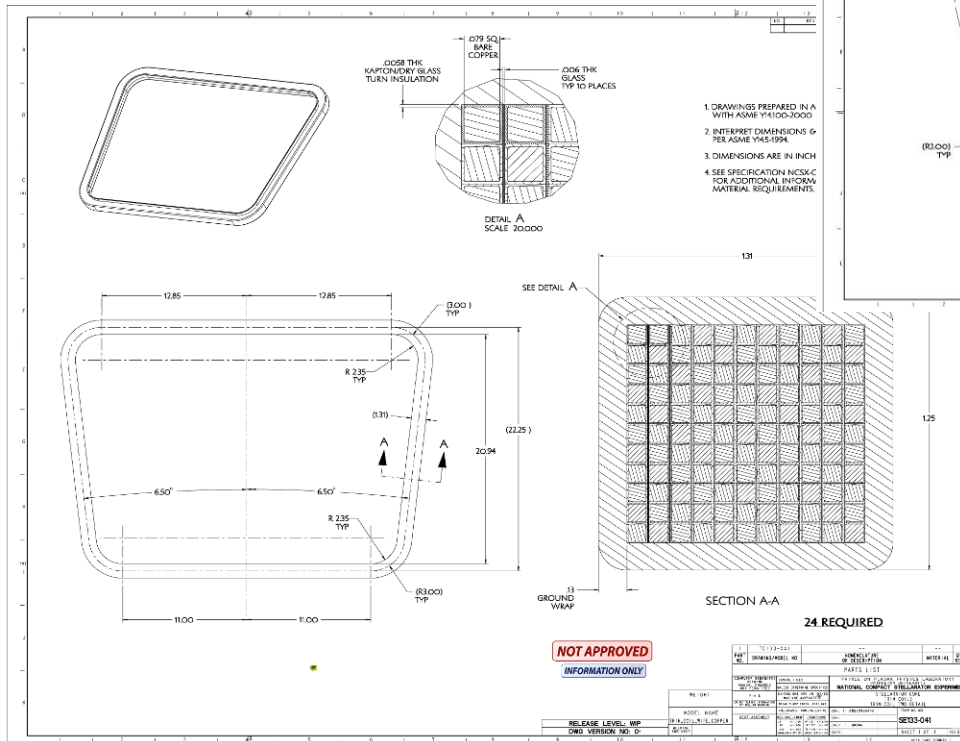


- 48 Coils
- Only two coil types
- All Coils Planar
- Top bottom symmetric half period patterns

Design - Trim Coils



- Coils Roughly 30 inches on a side
- Cross section just under 1.5 inches
- 2mm Conductor pre-insulated commercially available
- VPI with CTD 101K Epoxy

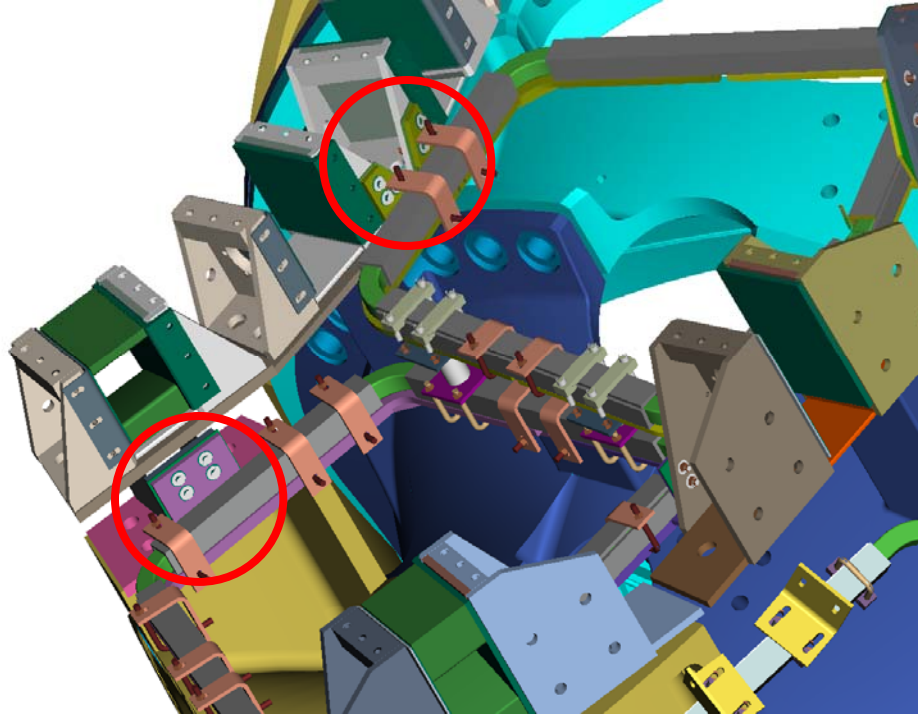


- 20 Kamp capability meets island suppression requirements with 100% margin

X, April 8-10, 2008
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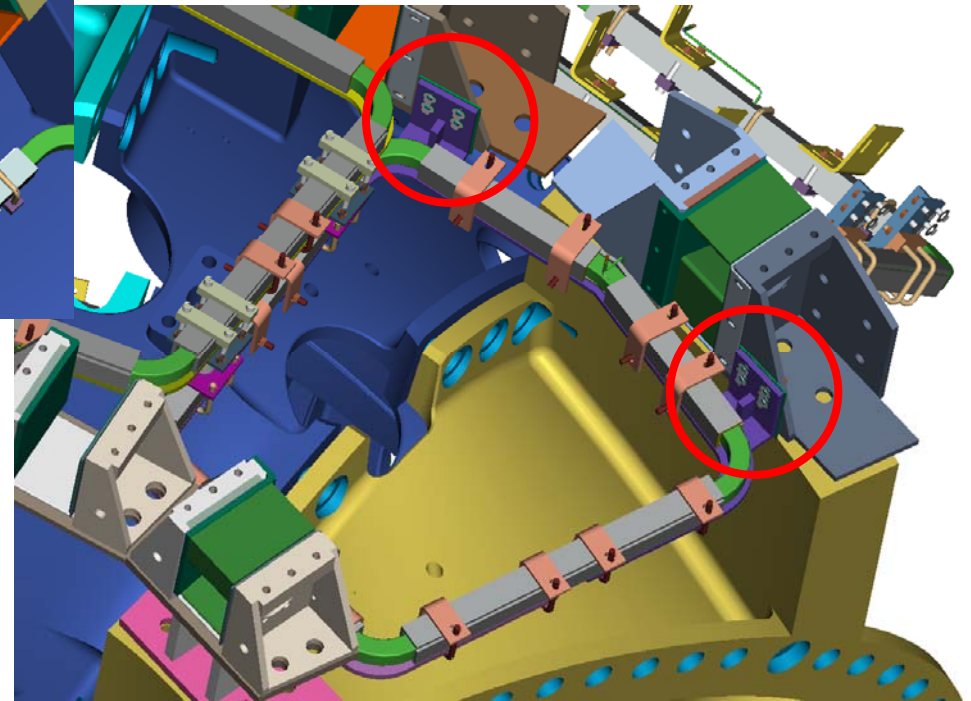


Design - Trim Coils Supports



- Coil Assemblies bolted to TF and PF Coils supports

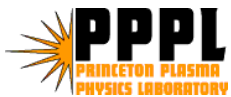
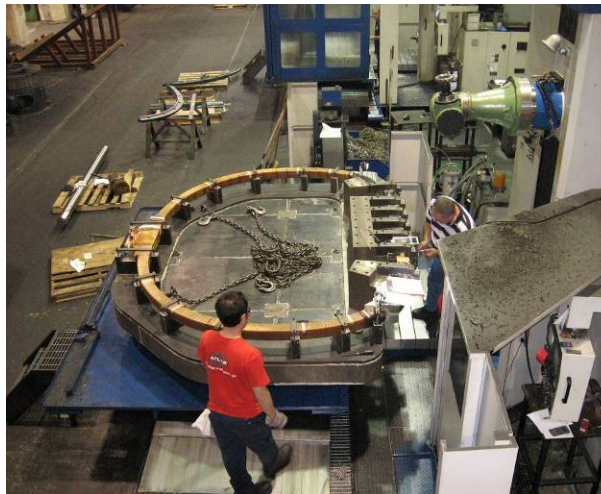
- Coil assemblies constructed by welding and clamping channels with a 1" thick picture frame base to straight legs



TF Fabrication Status



- 10 out of 18 TF Coils Complete
- Coil #11 in final testing and coil #13 completing winding
- Wedge Casting Deliveries from 2nd Tier Vendor back on track
- Fabrication now routine but close supervision continues



PF Procurement Status



- Long lead conductor order is placed
- Multiple Vendors have submitted bids for coils
- All bids meet project cost and schedule requirements
- Bid evaluation in process
- TF coil experience will expedite evaluation and oversight of PF coil vendors
 - Induction Brazing Process Developed
 - High Confidence in Maintenance of Geometry
 - VPI Process Developed and Proved out

Estimate, Basis

- TF Coil costs based on final payments for fixed contract costs and continued oversight by PPPL at historic levels
- PF Coil costs based on budgetary quotes, now verified by bids which fall within budget levels and PPPL oversight during fabrication
- Trim Coil costs based on budgetary quotes for coils and time and material estimates for supporting brackets

TF Coil Schedule



13 - Conventional Coils							
Job: 1361 - TF Fabrication-KALISH							
TF Title III and Fabrication Oversight							
131-033C		Title III engr,inspection, support	214*	02JAN08A	30OCT08	1,499	151,764.17
TF Fabrication Contract							
1361C-108		Fab, Test & Deliver Coil #8	21*	31JAN08	28FEB08	497	4,720.00
1361C-109		Fab, Test & Deliver Coil #9	1	24MAR08*	24MAR08	496	47,210.00

Kalish =175hr ;Meighan em/lb=43

48=47 ;

48=47 ;

- Coils #1 through #10 Complete
- Deliveries ahead of schedule
- 506 days float for coil #18
- Sub tier wedge casting vendor recently back on schedule
- Maintain Vigilance

Activity ID	MILE -STONE LEVEL	Activity Description	Duration (work days)	SHIFTS	Forecast Start	Forecast Finish	Total Float	Cost to Complete	FY08		FY09	
1361C-110		Fab, Test & Deliver Coil #10	1		15APR08*	15APR08	496	47,210.00				
1361C-111		Fab, Test & Deliver Coil #11	1		07MAY08*	07MAY08	496	47,210.00				
1361C-112		Fab, Test & Deliver Coil #12	1		30MAY08*	30MAY08	496	47,210.00				
1361C-113		Fab, Test & Deliver Coil #13	1		23JUN08*	23JUN08	506	47,210.00				
1361C-114		Fab, Test & Deliver Coil #14	1		16JUL08*	16JUL08	506	47,210.00				
1361C-115		Fab, Test & Deliver Coil #15	1		07AUG08*	07AUG08	506	47,220.00				
1361C-116		Fab, Test & Deliver Coil #16	1		29AUG08*	29AUG08	506	47,220.00				
1361C-117		Fab, Test & Deliver Coil #17	1		23SEP08*	23SEP08	506	47,220.00				
1361C-118		Fab, Test & Deliver Coil #18	1		15OCT08*	15OCT08	506	47,220.00				
1351-195X	2	ALL TF COILS DELIVERED	0			15OCT08	506	0.00				

48=47 ;

48=47 ;

48=47 ;

48=47 ;

48=47 ;

48=47 ;

48=47 ;

48=47 ;

48=47 ;

48=47 ;



PF Coil Schedule

Job: 1352 - PF Coil Procurement-CHRZANOWSKI								
PF Coil Fabrication								
141-038.1		PF Conductor Delivery	65	21FEB08A	08MAY08	1,621	200,210.40	41=161.2\$K ;
141-039		Bid & Award Materials	21	03MAR08*	31MAR08	1,581	8,500.80	CHRZANOWSKI =48hr ;
141-040		PF Materials Awarded	0		31MAR08	1,581	0.00	
1352-100		Materials Delivery PF 4,5,6	68	01APR08	07JUL08	1,581	168,502.14	41=136\$K ;
141-035		Bid & Award PF Coil Fabrication	60*	07MAR08*	30MAY08	303	34,276.00	CHRZANOWSKI=80hr ; 35=05\$K ; SV=80
141-036	2	PF Coils Awarded	0		30MAY08	303	0.00	
1352-121		Design/Fab Tooling for PF 5	85	02JUN08	30SEP08	304	273,900.00	48=273.9\$K ;
1352-122		Design/Fab Tooling for PF 6	85	02JUN08	30SEP08	303	320,100.00	48=320.1\$K ;
1352-145		Fabricate/Divr PF 5 & 6 Lower	95	01OCT08	23FEB09	304	156,519.00	48=153
1352-145M	2	PF 5&6 Lower Delivered	0		23FEB09	304	0.00	
1352-146		Fabricate/Divr PF 5 & 6 Upper	154	24FEB09	30SEP09	456	156,519.00	48=153
1352-120		Tooling for PF 4	55	01OCT08	18DEC08	303	73,656.00	48=72\$K ;
1352-151		Fabricate/Divr PF 4 lower & upper	194	19DEC08	30SEP09	303	41,124.60	48=40.2
141-031		Title III engr WBS 132	370	05MAY08	23OCT09	1,252	144,916.98	CHRZANOWSKI =392hr ; SV=392
141-901		PF5 Lower Inspection & Test	5	24FEB09	02MAR09	304	3,545.70	CHRZANOWSKI=10hr ; EM/TB =20hr ;
141-902		PF6 Lower Inspection & Test	5	24FEB09	02MAR09	304	3,545.70	CHRZANOWSKI=10hr ; EM/TB =20hr ;
141-905		PF5 Upper Inspection & Test	5	01OCT09	07OCT09	456	3,649.20	CHRZANOWSKI =10hr ; EM/TB =20hr ;
141-906		PF6 Upper Inspection & Test	5	01OCT09	07OCT09	457	3,649.20	CHRZANOWSKI =10hr ; EM/TB =20hr ;
141-900		PF4 Lower Inspection & Test	5	01OCT09	07OCT09	303	3,649.20	CHRZANOWSKI =10hr ; EM/TB =20hr ;
141-900A		PF4 Upper Inspection & Test	5	01OCT09	07OCT09	461	3,649.20	CHRZANOWSKI=10hr ; EM/TB =20hr ;
141-903		Refurbish PF 1a	20	08OCT10*	04NOV10	154	7,229.60	EM/TB =80hr ;

- Multiple Bids Received
- Vendors under evaluation
- All bids are within existing budget and schedule

- May 13th Target for Award
- Conductor Ordered
- 304 Days Float for most critical delivery of lower coils

Trim Coil Schedule



- PDR Complete
- FDR Pending
- Conductor is commercially available
- Brackets Simple Shapes
- Coil Delivery aggressive
- 218 days float for procurement award and coil delivery

Job: 1354 - Trim Coil Design & Procurement-KALISH								
Trim Coil **Updated estimate**								
TRIM-020		Trim Coil System Requirements Document	12	07FEB08A	15FEB08	223	2,762.76	kalish =24hr;
TRIM-030		Review and Approve SRD	5	18FEB08*	22FEB08	223	0.00	
TRIM-070		Prelim trim coil concept & reqmnts	50*	02JAN08A	11MAR08	218	12,397.00	kalish =100hr; RUSHINSKI=160hr; CRUIKSHANK=160
TRIM-071		Layout/Design coils & supports	29*	31JAN08*	11MAR08	218	30,051.26	kalish =80hr; RUSHINSKI=156hr; CRUIKSHANK=156
TRIM-080		Analysis	50*	02JAN08A	11MAR08	218	21,252.00	DAHLGREN=160
TRIM-090		Prepare for PDR	7	03MAR08	11MAR08	218	9,846.88	kalish =40hr; RUSHINSKI =12hr; CRUIKSHANK=12
TRIM-100		Trim Coil PDR	1	12MAR08	12MAR08	218	1,877.28	kalish =08hr;RUSHINSKI =04hr;
TRIM-101	2	** Trim Coil PDR **	0		12MAR08	218	0.00	
TRIM-110		Procure Trim Coil Insulation	50	13MAR08	21MAY08	311	70,396.56	41=56.677\$K;
TRIM-130		Prepare Conductor Procurement Spec	3	13MAR08	17MAR08	253	3,294.08	kalish =16hr;RUSHINSKI =04hr;
TRIM-140		Review and Approve Conductor Spec.	5	18MAR08	24MAR08	253	0.00	
TRIM-120		Procure Trim Coil Conductor	100	25MAR08	13AUG08	253	6,210.00	41=26.445\$K;
TRIM-170		Complete Trim Coil Detailed Drawings	15	13MAR08	02APR08	218	38,290.16	kalish =68hr; RUSHINSKI =114hr; CRUIKSHANK=114
TRIM-200		Assy drawings & parts list	10	03APR08	16APR08	218	20,190.00	kalish =36hr; RUSHINSKI =60hr; CRUIKSHANK=60
TRIM-210		Prepare for FDR	7	17APR08	25APR08	218	9,846.88	kalish =40hr; RUSHINSKI =12hr; CRUIKSHANK=12
TRIM-220		Trim Coil + Structure FDR	1	28APR08	28APR08	218	1,877.28	kalish =08hr; RUSHINSKI=04hr;
TRIM-221	2	** Trim Coil + Structure FDR **	0		28APR08	218	0.00	
TRIM-230		Resolve Chits	5	29APR08	05MAY08	218	4,250.40	kalish =24hr;
TRIM-150		Prepare Trim Coil Procurement Spec.	10	13MAR08	26MAR08	228	8,004.96	kalish =40hr; RUSHINSKI =08hr;
TRIM-160		Approve Procurement Spec	5	27MAR08	02APR08	228	0.00	
TRIM-240		Trim Coil Procurement	25	06MAY08	10JUN08	218	16,009.92	kalish =80hr;RUSHINSKI =16hr;
TRIM-250	2	AWARD TRIM COIL PROCUREMENT	0		10JUN08	218	0.00	
TRIM-260		Vendor Design and Fixture Fabrication	80	11JUN08	02OCT08	218	242,502.00	41=195\$K;
TRIM-270		Fabricate Trim Coils for FPA #1	0		02OCT08	218	0.00	41=55\$K; 48=112.4\$K;
TRIM-270M	2	Trim Coils for FPA #1 Delivered	45	03OCT08	08DEC08	218	0.00	
TRIM-275		Fabricate Trim Coils for FPA #2	45	03OCT08	08DEC08	217	171,250.20	48=167.4\$K;
TRIM-280		Fabricate Trim Coils for FPA #3	45	08DEC08	18FEB09	317	171,250.20	48=167.4\$K;
TRIM-300		Fabricate Brackets for 1st FPA	30	01JUL08*	12AUG08	299	150,729.12	41=121.36\$K;
TRIM-303		Fabricate Brackets for 2nd FPA	30	13AUG08	24SEP08	383	150,729.12	41=121.36\$K;
TRIM-306		Fabricate Brackets for 3rd FPA	30	25SEP08	05NOV08	383	157,460.55	41=121.36\$K;
TRIM-399		Title III support & oversight	231	11JUN08	14MAY09	1,368	134,970.34	chrzanowski =552hr; Rt EM/TB =144hr; 35=10\$



TF Coil Risk



Risk Retired

- Induction Brazing
- Locking Braze 1st Coil
- Fitting Lead Area
- VPI Process
- Wedge Straightness / Geometry
- Wedge Magnetic Permeability
- Maintaining Coil Geometry
- Wedge Angle Cut and Coil Tolerances
- Cryogenic Electrical Testing



Remaining Risk

- Bad Coil
Mitigation - Spare Copper available for one coil



PF and Trim Coil Risk and Mitigations



- Lack of qualified vendors bidding jobs
 - PF Coils presently in procurement with multiple bids
 - Trim Coil design kept simple to maximize bidders
- Quality Issues with vendors
 - Close monitoring of vendors with frequent PPPL visits and review
 - Detailed requirements called for in procurement specification
 - Detailed inspection, test and manufacturing documentation required
- Failure or loss of Coil during Fabrication or Assembly
 - Procurement of spare copper for one additional PF coil
 - One spare of each type of Trim Coil will be procured
- Schedule risk due to poor performance at vendors
 - Procurements accelerated to maximize float in schedule
 - Constant PPPL oversight with detailed schedule review at vendor