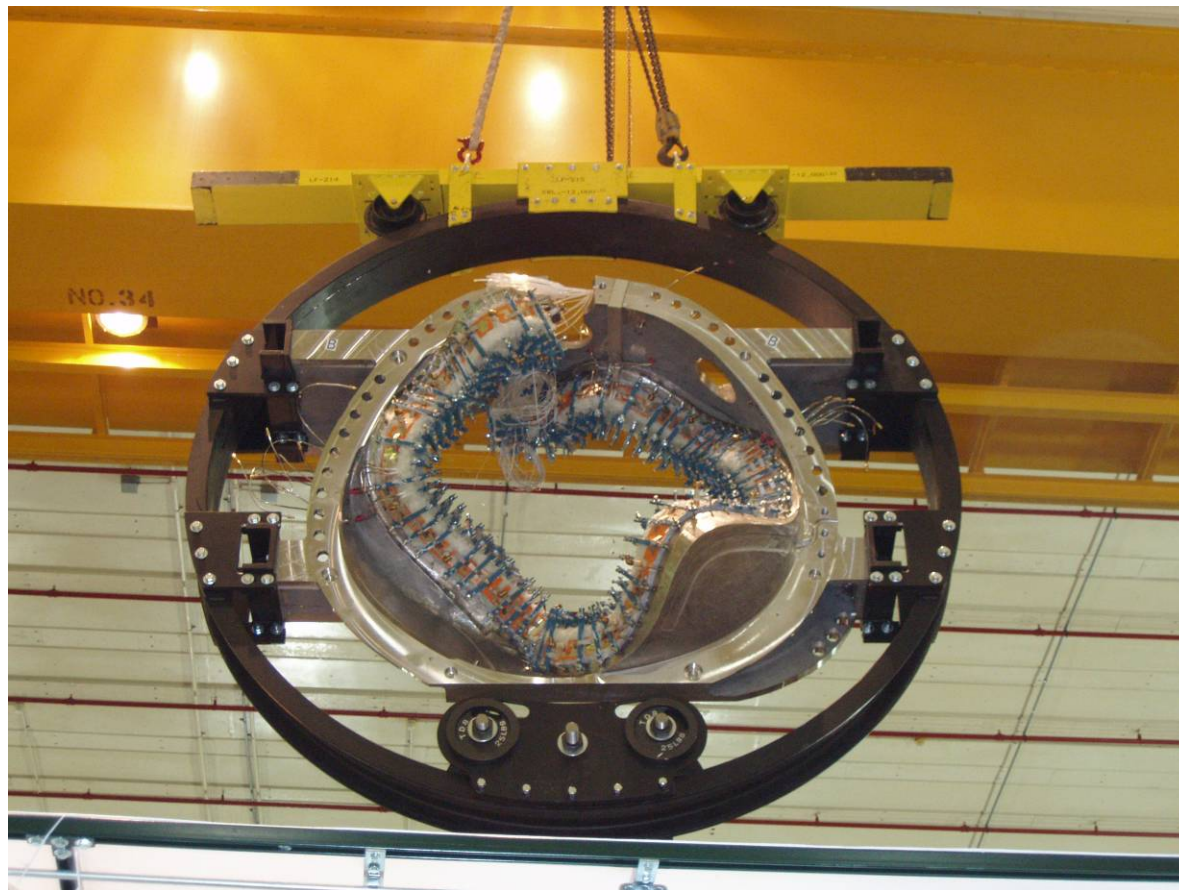


Modular Coil Manufacturing Update



J. H. Chrzanowski for the NCSX Project

Requirements, Design & Interfaces



- Requirements:
 - Manufacture 18 modular coils that meet the design requirements as defined in the GRD and SRD.
 - Maintain Stellarator symmetry
 - Maintain tight current center tolerances [± 0.5 mm accuracy]
 - Operate at liquid nitrogen temperatures
- Design:
 - Design documents are complete
 - SRD, Specifications, drawings, manufacturing procedures
- Interfaces:
 - MC interfaces with numerous systems as outlined in SRD
 - These interfaces are continuing to evolve as machine assembly is completed
 - Vacuum vessel, TF coils Cryo-systems, FPA, etc.



Modular Coil Status



- **Progress at last Project Meeting- August 16, 2007 :**
 - 13 Coils have been Vacuum Pressure Impregnated (VPI) and 14 through the winding process
- **Today's Status [April 8, 2008]**
 - 16 Coils have been VPI'd and 17 are through the winding process

MC ID Number	VPI Date	VPI Status	Post VPI Completion Date	Post VPI Status
A5	9-20-07	Complete	Complete	Complete
C6	2-14-08	Complete	4-18-08	In progress
B5	2-28-08	Complete	5-9-08	Not started
B6	5-15-08	Bag Mold Prep	6-23-08	Not started
A6	7-15-06	Pre-winding	9-17-08	Not started

- The last modular coil will be VPI'd by **July 15, 2008**
- All Post VPI work will be completed by **September 17, 2008**



Tracking Punch List Items



- Majority of punch list items have been completed.
- Remaining items include: Strain gages, additional thermocouples, flange interface modifications [as req'd]

Coil	Wound/ VPI Comp	¹ Coil Post- VPI Items	² Initial Elect. Testing	Ground Poloidal Break	Final Clamps (incl short clamps)	T-Couples Installed (coil area)	Insul Installed	Bushing Fab	Premeasure Metrology	Metrology (as cast)	Location	New Holes	Grind/ Mill (Nut Clearance)	Grinding (Overcast)	Comments
A-1	X	X	X	X	X	X	X	X	X	X	CWF		X	X	FPA
A-2	X	X	X	X	X	X	X	X	X	X	CWF		X	X	FPA
A-3	X	X	X	X	X	X	X	X	X	X	RWSF		X	X	
A-4	X	X	X	X	X	X	X		X		RESA		X	X	
A-5	X	X	X	X	X	X	X	X	X		RWSF				
A-6	W			X				X			CWF		X	X	
B-1	X	X	X	X	X	X	X	X	X	X	CWF		X	X	FPA
B-2	X	X	X	X	X	X	X	X	X	X	CWF		X	X	FPA
B-3	X	X	X	X	X	X	X	X	X		RWSF		X	X	
B-4	X	X	X	X	X	X	X	X	X	X	RESA		X		Grinding for gross fits
B-5	X										CWF				
B-6	W			X							CWF				
C-1	X	X	X	X	X	X	X	X	X	X	CWF	X	X	X	PRE FPA STEPS
C-2	X	X	X	X	X	X	X	X	X	X	RWSF	X	X	X	
C-3	X	X	X	X	X	X	X	X	X	X	RWSF	X	X	X	
C-4	X	X	X							X	RESA	X	X	IP	Grinding for gross fits
C-5	X	X	X	X	X	X		X	X	X	CWF				
C-6	X										CWF				

KEY

X	Done	IP	In Progress	W	Winding	¹	Diag box, loops, lock clamps etc.	²	Includes hipot to 7.5 kV
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Cost and Schedule



- Modular Coil cost estimate is based upon detail task breakdown and actual in-field times to complete coils
 - Based on: 17 coils wound and 16 VPI'd
- Budget increased for procurement and installation of additional thermocouples that were added to the design
- Budget increased additional shop hours - unidentified work associated with modifications of winding forms during fit-up in support of FPA
- Last Modular Coil will be VPI'd by 7/15/08 [target date]
- Post VPI items complete by 9/17/08
- Punch list items complete by 11/6/08



Schedule



Job: 1408 - MC Winding Supplies-CHRZANOWSKI

1408-2	Epoxy (existing order)	256*		23MAY07A	02JUN08	1,605	19,002.60	41=45\$k ;
1408-3	Misc and safety supplies (\$7k/mo.)	276*		23MAY07A	30JUN08	1,585	40,476.78	41=84\$k ;
1408-4.0	Order Strain Gages	1		14MAR08*	14MAR08	170	0.00	
1408-4.1	Procure Strain Gages	55		17MAR08*	02JUN08	170	37,260.00	41=38\$k ;
1408-5	Epoxy/glass for mold shell	255*		23MAY07A	30MAY08	1,606	5,439.96	41=13\$k ;
1408-6	VPI clean manifold contract	276*		23MAY07A	30JUN08	1,585	4,818.96	41=10\$k ;
1408-8	Cutting hardware for flange bolts	276*		23MAY07A	30JUN08	1,585	1,440.72	41=3k ;
1408-7	Misc tech shop support	276*		23MAY07A	30JUN08	1,585	19,609.83	EMT/TB =640 ;

Job: 1451 - Mod Coil Winding-CHRZANOWSKI

Station 2-Winding, Instl Chill Plates,Tubing,Bag

P3-080	Instl Chill Plates,Tubing,Bag B5	38*	1	20DEC07A	20FEB08	216	8,048.62	EM/TB =728
P3-161	Wind coil B6	78*	1	01NOV07A	29FEB08	149	12,169.27	EM/TB =1609 EMT/TB =32 ;

Station 3-Casting Prep & Winding

P1-151	Receive A6, Prep& Instl Cladding	97*	1.5	01NOV07A	27MAR08	93	30,206.03	EM/TB =244hr ; EMT/TB =124 EM2/TB =245 ;
P1-161	Wind coil A6	75	1	28MAR08	27MAY08	93	121,692.77	EM/TB =1609 EMT/TB =32 ;
P1-170	Instl Chill Plates,Tubing,Bag A6	44	1	28MAY08	29JUL08	93	57,490.16	EM/TB =728

Station 4-Winding, Instl Chill Plates,Tubing,Bag

P3-170	Instl Chill Plates,Tubing,Bag B6	42	1	31JAN08A	02JUN08	149	57,490.16	EM/TB =728
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Station 5-VPI

P2-051V	VPI (Station 5) C6	12*	1	31JAN08A	15FEB08	193	34,225.58	EM/TB =281hr ; EM2/TB =277 ; EMT/TB =16 ;
P2-171V	VPI (Station 5) B5	19*	1	21FEB08	18MAR08	216	47,514.31	EM/TB =281hr ; EM2/TB =277 ; EMT/TB =16 ;
P3-171V	VPI (Station 5) B6	19	1	03JUN08	27JUN08	149	47,514.31	EM/TB =281hr ; EM2/TB =277 ; EMT/TB =16 ;
P1-171V	VPI (Station 5) A6	19	1	30JUL08	25AUG08	93	47,514.31	EM/TB =281hr ; EM2/TB =277 ; EMT/TB =16 ;
P3-171VM	2 COMPLETE VPI OF 18th MOD COIL	0	1		25AUG08	93	0.00	▼

Last VPI



Schedule-continued



Station 1 Post VPI								
P2-051C	Final Clamps & Warm Test (Station1) C6	43	1	18FEB08	16APR08	193	24,006.88	EM/TB =272 EMT/TB =32
P3-171C	Final Clamps & Warm Test (Station1) B5	16	1	17APR08	08MAY08	195	24,006.88	EM/TB =272 EMT/TB =32
P2-171C	Final Clamps & Warm Test (Station1) B6	16	1	30JUN08	22JUL08	149	24,006.88	EM/TB =272 EMT/TB =32
P1-171C	Final Clamps & Warm Test (Station1) A6	16	1	26AUG08	17SEP08	93	24,006.88	EM/TB =272 EMT/TB =32
LOE Oversight & Supervision								
145XSPRV-2	Winding Engineering oversight and supervision	314*		01MAY07A	31JUL08	1,563	74,971.74	Raftopoulos=70hrs/mo.
145XSPRV-3	Winding Engineering oversight and supervision	356*		01MAY07A	30SEP08	1,521	84,886.56	Languish=70 hrs/mo.
145XSPRV-A	Winding Engineering oversight and supervision	185*		01NOV07A	31JUL08	1,563	189,776.65	Chrzanowski=120hrs/mo.,Meighan=120 hrs/mo.
Job: 1459 - Mod Coil Fabr.Punch List-CHRZANOWSKI								
Punchlist Tech shop/RESA								
PLTS-C3	Grinding & Drill Holes -C3	102*	1	01OCT07A	03MAR08	187	8,339.23	EM/TB =240hr :
PLTS-C4	Grinding & Drill Holes -C4	5	1	01OCT07A	10MAR08	214	17,815.63	EM/TB =240hr :
PLTS-C5	Grinding & Drill Holes -C5	5	1	01OCT07A	17MAR08	1,659	18,763.27	EM/TB =240hr :
PLTS-B5	Grinding -B5	5	1	09MAY08	15MAY08	195	3,869.53	EM/TB =49hr :
PLTS-A6	Grinding -A6	5	1	01OCT07A	19SEP08	93	270.87	EM/TB =49hr :
PLTS-B6	Grinding -B6	5	1	23JUL08	29JUL08	149	3,869.53	EM/TB =49hr :
PLTS-C6	Grinding & Drill Holes -C6	20	1	17APR08	14MAY08	193	18,952.80	EM/TB =240hr :
PLTS-GRIND	Coil to coil fitup modifications (grinding/cp)	165*	1	01DEC07A	31JUL08	1,563	69,177.72	EM/TB =878hr :
Punchlist- Coil Technicians								
PLCT-A3	Insul,measure,TC, other punch list-A3	17	1	05JUL07A	14FEB08	174	2,854.77	EM/TB =241hr :
PLCT-A4	Insul,measure,TC, other punch list-A4	17	1	06JUL07A	05MAR08	174	11,990.02	EM/TB =241hr :
PLCT-B3	Insul,measure,TC, other punch list-B3	14	1	01OCT07A	20MAR08	174	2,114.82	EM/TB =208hr :
PLCT-C3	Insul,measure,TC, other punch list-C3	18	1	01OCT07A	07APR08	174	10,431.15	EM/TB =259hr :
PLCT-B4	Insul,measure,TC, other punch list-B4	14	1	01OCT07A	21APR08	174	1,464.10	EM/TB =208hr :
PLCT-C4	Insul,measure,TC, other punch list-C4	14	1	25JUL07A	02MAY08	184	10,461.95	EM/TB =278hr :
PLCT-A5	Insul,measure,TC, other punch list-A5	14	1	30JUL07A	12MAY08	184	13,502.29	EM/TB =208hr :
PLCT-A6	Insul,measure,TC,SG other punch list-A6	14	1	01OCT07A	09OCT08	93	13,895.54	EM/TB =208hr :
PLCT-B5	Insul,measure,TC, other punch list-B5	14	1	01OCT07A	23OCT08	93	14,288.80	EM/TB =208hr :
PLCT-C5	Insul,measure,TC, other punch list-C5	18	1	01OCT07A	06NOV08	93	4,475.17	EM/TB =255hr :
PLCT-B6	Insul,measure,TC,SG other punch list-B6	14	1	01OCT07A	18AUG08	149	13,502.29	EM/TB =208hr :
PLCT-C6	Insul,measure,TC,SG other punch list-C6	14	1	01OCT07A	04JUN08	193	13,436.75	EM/TB =205hr :
PLCT-C6M	COMPLETE MODULAR COIL FABRICATION	0	1		04JUN08	193	0.00	
PLCT-CRANE	Crane support	207*	1	01DEC07A	30SEP08	1,521	31,310.03	EM/TB =480hr :

Post VPI items complete


Punch list items complete

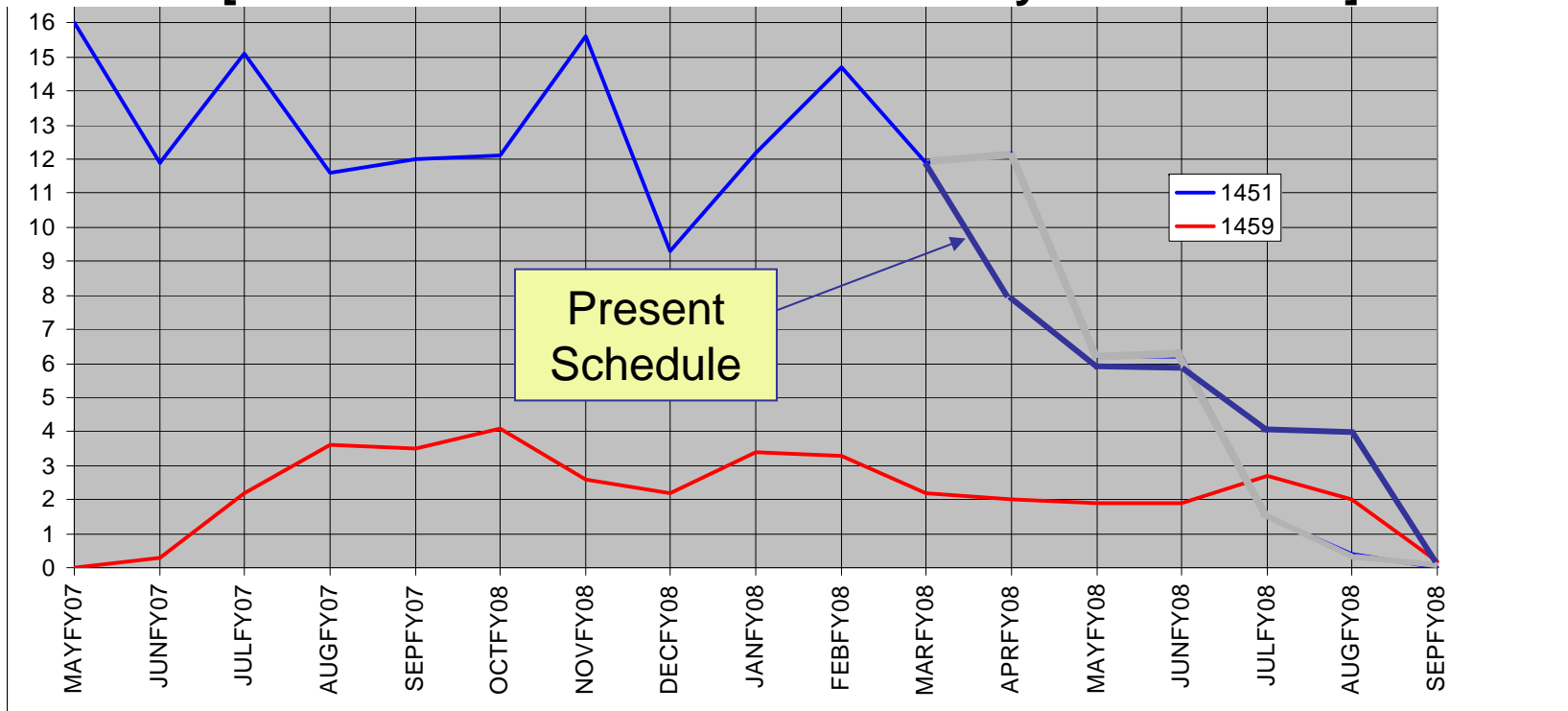


Manpower Down Sizing Plan



- **MC Manpower Plan:**

- Presently working single shift x 5 days a week
- We have a plan for the orderly down sizing of modular coil manufacturing team
- Size of production team will vary as required to complete modular coils [Peak 18 technicians  today 8 technicians]



Manufacturing Area



- We have begun transferring real estate to FPA teams as MC stations are shut down.
- Station 2 winding station was transferred to FPA on 3/1/08
- By 7/31/08 all areas except for Station 4 and the autoclave will be transferred to FPA



Uncertainty of Estimate



NCSX June 2007 ETC
TABLE IV - Uncertainty of Estimate and Residual Risk Assessment

WBS Number: 142
WBS Title: Windings and Assembly
Job Numbers: 1408, 1451, & 1459
Job Title: Modular Coil Winding Supplies (1408)
Job Title: Modular Coil Winding Operations (1451)
Job Title: Modular Coil Punch List Items (1459)
Job Manager: Jim Chrzanowski

<u>Uncertainty of the Estimate</u>				<u>Uncertainty Range (%)</u>	<u>Comments/Other Considerations</u>
	<u>High</u>	<u>Medium</u>	<u>Low</u>		
Job 1408					
Design Maturity	X			-5%/+10%	Mostly off-the-shelf items
Design Complexity			X		Mostly off-the-shelf items
Job 1451					
Design Maturity	X			-10%/+15%	Known and proven procedures and processes
Design Complexity		X			Have built & Test 14 coils and have proven processes even with tight metrology and tolerances.
Job 1459					
Design Maturity		X		-10%/+15%	Still uncertainty on number of field changes (e.g., number of holes, etc.)
Design Complexity			X		Standard field work.

Note: High/Medium/Low uncertainty assessment from Job Manager. Uncertainty range based on AACEI recommended practice 18R-97 as amended for NCSX

High level of confidence in estimate



NCSX June 2007 ETC
TABLE IV - Uncertainty of Estimate and Residual Risk Assessment

Residual Impacts					Cost Impact		Schedule Impact			
Job	Risk Description	Likelihood of Occurring	Mitigation Plan	Basis of estimate	Low	High	Low	High		
1408	NONE									
1451	Damage or loss of modular coil during VPI or testing requiring the conductor to be stripped off and re-wound (Please see Assumptions)	U	Continue to use same rigorous process used for first 12 coils during which there were no fabrication mishaps requiring re-winding a path.	~\$35K in materials; ~\$380K in labor. 7.5 months to do work with the potential for a 2 month impact on the critical path.	+\$400	+\$450	+ 0.00	+ 2.00	RR#6	16 of 18 coils successfully wound. Remaining 2 coils in winding process.
1451	Failure of major piece of winding equipment (e.g., motor, gear box, etc.) resulting in extended downtime in a winding station	U	Critical spare components are available from winding station #2 that is no longer being used	~\$5K for repair costs	+\$5	+\$10	+ 0.00	+ 0.00	RR#7	Future risk, has not occurred yet - N/A
1451	Insulation on modular coil fails during initial cooldown and testing requiring stellarator core disassembly	NC	C1 tested at full current at cryogenic temperature. All modular coils will be tested at RT at elevated (50% higher) voltage for faults to ground. In addition, routine field tests will be performed on each assembly station to ensure that the electrical	High impact-low probability event not covered by contingency					RR#7	16 of 18 coils successfully wound. Remaining 2 coils in winding process.

2-3 month impact on project schedule [if coil 18 had to be replaced]

Results in highest impact [7.5 months to replace coil]

[14 coils have been electrically tested]

Notes:

- [1] Low cost and schedule impacts are considered the minimum (0-percentile) impacts should the event occur. High cost and schedule impacts are considered the maximum (100-percentile) impacts should the event occur
- [2] Cost impacts should be entered as man-hours (by demographic) and M&S direct cost under basis of estimate. Cost impacts should NOT include standing army costs which are separately calculated from the schedule impact. Project control is responsible for quantifying the low and high cost impacts based on the labor hours and M&S identified
- [3] The schedule impacts should be entered as the min and max impacts on the critical path. If there is no critical path impact then the schedule entries should be zero.
- [4] Likelihood of occurrence should be entered consistent with our risk classification methodology, i.e. VL= Very Likely (P>80%), L=Likely (80%>P>40%), U=Unlikely (40%>P>10%), VU=Very Unlikely (P<10%), NC=Non-credible (P<1%)

Use three remaining winding

Assumptions

Cost: Would need ~\$4.5K of Epoxy + ~\$3K of insulation + \$1.5K of shell + ~\$5K of other misc components/materials + cost of new lead blocks of ~\$15K => round off to ~\$35K. Labor ~\$380K assuming ~4.5 months to rework and redo coil.

Schedule: To redo the coil: Need 138 shifts x 3 men/shift x 8 hours/shift => 3 months + To rework of ~65 shifts x 3 men/shift x 8 hours/shift => 1.5 months. Need an additional ~3 months to order lead blocks if needed. Anticipate ~3 months to re-order and obtain new lead blocks. If Type B coil is the one to fail, could add 1-2 months to critical path at an added "standing army" cost of ~\$260K/months or ~\$520K.

In Summary....



- 17 modular coils have been wound and 16 VPI'd
- Have begun down sizing of coil manufacturing team from peak level of 18 technicians to today's level of 8 technicians
- Have begun transferring manufacturing real estate to FPA teams
- Successfully addressed all of the technological challenges.
- **Safety** continues to be in the forefront of all planning and performance of field activities
- *The NCSX Project is committed to completing the manufacturing of the Modular coils by September 2008. (inc. final electrical tests)*

