

NCSX June 2007 ETC
TABLE III - Fabrication and Assembly

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

Fabrication and Assembly

Conditions and Basis for Estimate
1) All estimates are based on work performed from May 1, 2007 through the end of modular coil fabrication program
2) Estimates are based on actual in-field times as well as consultation with metrology personnel and technicians
3) M&S based upon actual contracts and monthly M&S supporting winding activities on first nine coils - see specifics in M&S below

TASK DESCRIPTION		EAEM	EAEM	EMSM	EMEM				
		Chr.	Raft	Meighan	Languish				
		hours	hours	hours	hours				
Engineering and Oversight		70%	40%	70%	40%				
LOE	9450-1***-1451	120	70 hr/month through completion of winding	120 hr/month	70 hr/month				
nominal hours for 14mo. Production		1680	980	1680	980				

TASK DESCRIPTION	Job Number	Total Shifts	No. of Coil tech per shift	Coil Tech [hours per shift]	Coil Tech [hours per coil]	Tech Shop Support [hours]	No. of coils	Total Manhrs	COILS
RESA Building Activities									
Unload & unbox winding form	9450-1***-1459	0.5	0	0	0	12	5	60	B5 & B6; A5 & A6; C6
Inspect casting [surfaces, magnetic permeability]	9450-1***-1451	0.5	1	9	4.5	0	5	22.5	B5 & B6; A5 & A6; C6
Winding form modifications [grinding, welding, deburring, etc.]	9450-1***-1459	3	0	0	0	48	5	240	B5 & B6; A5 & A6; C6
Station 1a/4 Activities									
Position & mount WF to support ring	9450-1***-1451	2	3	9	54	32	6	516	B4 thru B6; A5 thru A6; C6
Install coil in station 4 turning fixture	9450-1***-1451	1	3	9	27	16	6	258	B4 thru B6; A5 thru A6; C6
Install weights and balance casting and ring assembly	9450-1***-1451	1	2	10	20	0	6	120	B4 thru B6; A5 thru A6; C6
Weld monuments, stud adapters & lead nuts	9450-1***-1451	2.5	1	9	22.5	16	7	269.5	B3 thru B6; A5 thru A6; C6
Measure casting wings using metrology equipment	9450-1***-1451	2	2	8	32	0	5	160	B5 thru B6; A5 thru A6; C6
Install studs for winding clamps	9450-1***-1451	2	3	9	54	0	7	378	B3 thru B6; A5 thru A6; C6
Electrical test poloidal break	9450-1***-1451	0.5	1	9	4.5	0	7	31.5	B3 thru B6; A5 thru A6; C6
Clean casting [inspect and clean all holes]	9450-1***-1451	1	2	9	18	0	7	126	B3 thru B6; A5 thru A6; C6
Install Kapton edging and mold release winding surface	9450-1***-1451	2	2	9	36	0	7	252	B3 thru B6; A5 thru A6; C6
Fitup Lead blocks and terminals [Remove lead blocks]	9450-1***-1451	1	2	9	18	0	7	126	B3 thru B6; A5 thru A6; C6
Cladding final clean & Kapton [Parallel activity]	9450-1***-1451	7	1	9	63	0	6	378	B4 thru B6; A5 thru A6; C6
Install inner cladding plates and cooling Tubes	9450-1***-1451	5	3	9	135	0	7	945	B3 thru B6; A5 thru A6; C6
		27			488.5	124		3882.5	TOTALS hours

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Coil Winding Station 2 and 3									
Prep for Winding									
Prepare coil for transfer	9450-1***-1451	0.5	2	9	9	0	7	63	B3 thru B6; A5 thru A6; C6
Install winding form in turning fixture	9450-1***-1451	1	3	8	24.0	16.0	7	280	B3 thru B6; A5 thru A6; C6
Install upper Tee for coil clamps	9450-1***-1451	2	2	9	36.0	0.0	7	252	B3 thru B6; A5 thru A6; C6
Install/set winding clamps side bars A & B	9450-1***-1451	4	3	9	108.0	0.0	7	756	B3 thru B6; A5 thru A6; C6
Prep groundwrap insulation [Parallel activity]	9450-1***-1451	6	1	9	54.0	0.0	7	378	B3 thru B6; A5 thru A6; C6
Re-install G-11 lead blocks- sides A & B	9450-1***-1451	1	2	9	18.0	0.0	8	144	B3 thru B6; A4 thru A6; C6
Position inner GW insulation onto winding form (sides A & B)	9450-1***-1451	7	2	9	126.0	0.0	8	1008	B3 thru B6; A4 thru A6; C6
Position lacing strips sides A & B	9450-1***-1451	2	2	9	36.0	0.0	8	288	B3 thru B6; A4 thru A6; C6
Wind Side "A"									
Braze & secure 1st. coil lead set [inc. brazing]	9450-1***-1451	2	2	9	36.0	0.0	8	288	B3 thru B6; A4 thru A6; C6
Position leads & Wind side A	9450-1***-1451	12	2.5	10	300.0	0.0	8	2400	B3 thru B6; A4 thru A6; C6
Reposition coil from side A to side B	9450-1***-1451	1	3	8	24.0	16.0	8	320	B3 thru B6; A4 thru A6; C6
Wind Side "B"									
Braze & secure 1st. coil lead set [inc. brazing]	9450-1***-1451	2	2	9	36.0	0.0	8	288	B3 thru B6; A4 thru A6; C6
Position leads & Wind side B	9450-1***-1451	12	2.5	10	300.0	0.0	8	2400	B3 thru B6; A4 thru A6; C6
Final coil winding activities									

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Job Manager: Jim Chrzanowski

Fabrication and Assembly

- Conditions and Basis for Estimate**
1) All estimates are based on work performed from May 1, 2007 through the end of modular coil fabrication program
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Measure, reposition & re-measure coil bundle [sides A & B]	9450-1****-1451	8	3	9	216.0	0.0	8	1728	B3 thru B6; A4 thru A6; C6
Secure Lacing	9450-1****-1451	2	2	9	36.0	0.0	8	288	B3 thru B6; A4 thru A6; C6
Complete groundwrap installation	9450-1****-1451	6	2	9	108.0	0.0	8	864	B3 thru B6; A4 thru A6; C6
<i>Unanticipated Delays/Rework Activities</i>									
Tasks TBD	9450-1****-1451	3	3	9	81.0	0	8	648	
		35.75			1548	32		12393	TOTALS hours

Final Coil prep & Mold Application [Stations 2 & 3]									
TASK DESCRIPTION	Job Number	Total Shifts	No. of Coil tech per shift	Coil Tech [hours per shift]	Coil Tech [hours per coil]	Tech Shop Support [hours]	No. of coils remaining	Total Manhrs Revised	COILS
Final Coil Prep									
Clean chill plates [Parallel activity]	9450-1****-1451	4	1	9	36	0	8	288	Coils A4-A6; B3-B6 and C6
Install chill plates & Tubing	9450-1****-1451	12	2.5	9	270	0	8	2160	Coils A4-A6; B3-B6 and C6
Cut, braze, silverplate and position 2nd. coil lead set [side A]	9450-1****-1451	3	2	9	54	0.0	8	432	Coils A4-A6; B3-B6 and C6
Cut, braze, silverplate and position 2nd. Coil lead set [side B]	9450-1****-1451	3	2	9	54	0.0	8	432	Coils A4-A6; B3-B6 and C6
Soft solder and clean all lead joints	9450-1****-1451	2	1	9	18	0.0	8	144	Coils A4-A6; B3-B6 and C6
Install outer co-wound Diagnostic loops	9450-1****-1451	2	2	9	36	0	8	288	Coils A4-A6; B3-B6 and C6
Measure position of co-wound diagnostic loops	9450-1****-1451	1	2	9	18	0	8	144	Coils A4-A6; B3-B6 and C6
<i>Perform pre-VPI elect. & pressure tests</i>									
Pressure test cryo lines	9450-1****-1451	1	2	9	18	0	8	144	Coils A4-A6; B3-B6 and C6
Perform preliminary [pre-vpi] electrical tests	9450-1****-1451	0.5	2	10	10	0	8	80	Coils A4-A6; B3-B6 and C6
<i>Install bag mold around modular coil</i>									
Prep sprue sub-assemblies [Parallel activity]	9450-1****-1451	1	1	9	9	0	8	72	Coils A4-A6; B3-B6 and C6
Prep lead sprue sub-assemblies [Parallel activity]	9450-1****-1451	0.5	1	9	4.5	0	8	36	Coils A4-A6; B3-B6 and C6
Install G-11 final clamp pads & sprue bases	9450-1****-1451	1	2	9	18	0	8	144	Coils A4-A6; B3-B6 and C6
Finalize and secure G-11 lead box	9450-1****-1451	1	1	9	9	0	8	72	Coils A4-A6; B3-B6 and C6
Install glass roving and sheet over chill plates	9450-1****-1451	1	2	9	18	0	8	144	Coils A4-A6; B3-B6 and C6
Install silicone bag & sprues	9450-1****-1451	5	2	9	90	0	8	720	Coils A4-A6; B3-B6 and C6
Vacuum pumpdown/ RTV overcoat & leak repair	9450-1****-1451	2	3	9	54	0	9	486	Coils A4-A6; B2-B6 and C6
Install epoxy shell	9450-1****-1451	2.5	3	9	67.5	0	9	607.5	Coils A4-A6; B2-B6 and C6
		21.25			784	0		6393.5	TOTALS hours

VPI Activities (Station 5)									
TASK DESCRIPTION	Job Number	Total Shifts	No. of Coil tech per shift	Coil Tech [hours per shift]	Coil Tech [hours per coil]	Tech Shop Support [hours]	No. of coils remaining	Total Manhrs	COILS
Final VPI Prep									
Prepare MC for transfer	9450-1****-1451	0.5	2	9	9	0	9	81	Coils A4-A6; B2-B6 and C6
Transfer modular coil to Autoclave	9450-1****-1451	1	3	8	24	16	9	360	Coils A4-A6; B2-B6 and C6
Prepare MC for VPI [Connect fill lines & TC; leak check]	9450-1****-1451	3	3	8	72	0	9	648	Coils A4-A6; B2-B6 and C6
Vacuum pumpdown & preheat mold and autoclave	9450-1****-1451	2	3	10	60	0	9	540	Coils A4-A6; B2-B6 and C6
<i>VPI modular coil</i>									
Epoxy mix and fill coil	9450-1****-1451	1	4	12	48	0	9	432	Coils A4-A6; B2-B6 and C6
Temperature rampup and Cure	9450-1****-1451	3	2	12	72	0	9	648	Coils A4-A6; B2-B6 and C6
Temperature rampup and Post cure	9450-1****-1451	2	2	12	48	0	10	480	Coils A4-A6; B1-B6 and C6
Temperature rampdown	9450-1****-1451	1	1	10	10	0	10	100	Coils A4-A6; B1-B6 and C6
Cleanup & ready autoclave for coil removal	9450-1****-1451	2	3	10	60	0	10	600	Coils A4-A6; B1-B6 and C6
Rebuild manifolds and prep autoclave for next VPI	9450-1****-1451	5	3	10	150	0	10	1500	Coils A4-A6; B1-B6 and C6
		20.5			553	16		5389	TOTALS hours

Post VPI Activities (Station 1)									
TASK DESCRIPTION	Job Number	Total Shifts	No. of Coil tech per shift	Coil Tech [hours per shift]	Coil Tech [hours per coil]	Tech Shop Support [hours]	No. of coils remaining	Total Manhrs	COILS
Prepare coil for transfer	9450-1****-1451	0.5	2	9	9	0	10	90	Coils A4-A6; B1-B6 and C6
Transfer modular coil from Autoclave to Station #1	9450-1****-1451	1	3	8	24	16	10	400	Coils A4-A6; B1-B6 and C6
Remove studs, structural shell & sprues	9450-1****-1451	8	2	9	144	0	11	1584	Coils A3-A6; B1-B6 and C6

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Install final coil clamps	9450-1****-1451	3	2	9	54	0	11	594	Coils A3-A6; B1-B6 and C6
Perform (room temperature) electrical & Pressure Tests	9450-1****-1451	1	2	9	18	0	11	198	Coils A3-A6; B1-B6 and C6
Remove coil from ring assembly	9450-1****-1451	1	3	10	30	16	11	506	Coils A3-A6; B1-B6 and C6
		14.5			279	32		3372	TOTALS hours
					311				

Punch List Items	Job Number	Total Shifts	No. of Coil tech per shift	Coil Tech [hours per shift]	Coil Tech [hours per coil]	Tech Shop Support [hours]	No. of coils remaining	Total Manhrs	COILS
Mount diagnostic boxes	9450-1****-1459	0.5	2	9	9	0	18	162	All coils
Route and secure diagnostic wires to box	9450-1****-1459	0.5	2	9	9	0	18	162	All coils
Install final clamps [coils previously finished]	9450-1****-1459	3	2	9	54	0	6	324	Coils A1; C1 thru C5
Finalize cooling tubes	9450-1****-1459	1	2	9	18	0	18	324	All coils
Install Rogowski coils	9450-1****-1459	2	2	9	36	0	2	72	Coils A3 and A4
Test thermocouples & strain gages [15 min/unit]	9450-1****-1459	0	0	0	0	134	1	134	[134 strain gauges/ 600 TC]
Install strain gauges and thermocouples [2 hrs./SG or TC]	9450-1****-1459	0	1	0	41	0	18	738	[134 strain gauges/ 600 TC]
Measure final coil clamp surfaces	9450-1****-1459	1.5	2	9	27	0	18	486	All coils
Install Thermal Insulation over coil	9450-1****-1459	3	2	9	54	0	18	972	All coils
Replace co-wound loop on C4	9450-1****-1459	1	2	9	18	0	1	18	Coil C4
Install additional flange holes [12 per type "C" winding form]	9450-1****-1459	0	0	0	0	192	6	1152	[16 hr/hole]
Measure as built coils as required	9450-1****-1459	2	2	9	36	0	18	648	
Ground Poloidal Break Hardware	9450-1****-1459	0	0	0	0	2	18	36	All coils
Ground lead jumper studs	9450-1****-1459	0.2	1	8	1.6	0	18	28.8	All coils
Grind flange pockets for hardware	9450-1****-1459	0	0	0	0	440	1	440	[60] holes @ 2hr ea. & [20] holes @ 16hr ea.
Grind winding form wings/clearances	9450-1****-1459	0	0	0	0	24	18	432	All coils
insert repair						200		200	A1(2 holes) B2(8 holes)
								6328.8	TOTALS hours

MATERIAL & SUPPLIES	Job Number	Coil Tech [hours per shift]	Coil Tech [hours per coil]	Tech Shop Support [hours]	No. of coils remaining	TOTAL Tech Hours	M&S w/o G&A	COILS
Coil Supplies								
1) Insulation	9450-1****-1408		0	0	9		\$8,000.00	
2) Epoxy- CTD-101 [\$4500.00 per coil @ assume 9 injections]	9450-1****-1408		0	0	9		\$45,000.00	Coils A4-A6; B2-B6 and C6
3) Miscellaneous and safety supplies [@ \$7000/month]	9450-1****-1408		0	0	9		\$63,000.00	
4) Strain gages and thermocouples	9450-1****-1459						\$90,000.00	TC.\$80each x600=\$48k; SG \$290 each x 62=\$18k FB SG \$277eachx72=\$20k;misc \$4k
5) Cutting hardware for flange bolts	9450-1****-1459						\$3,000.00	
VPI Supplies								
1) Epoxy/glass for mold shell [Hysol]	9450-1****-1408		0	0	9		\$13,000.00	
2) VPI clean manifold contract [\$1100.00 per VPI]	9450-1****-1408		0	0	9		\$10,000.00	
Tech Shop Support-								
Miscellaneous activities- TBD	9450-1****-1408		0	80	8	640		Coils A4-A6; B3-B6 and C6
	9450-1****-1459							
							\$232,000.00	TOTALS

	\$/ Gallon	Gal/coil	per coil	No. coils	
Hysol 2039 Resin	\$82.00	4.5	\$369.00	9	\$3,321.00
Hysol 3561 Hardener	\$211.00	1.5	\$316.50	9	\$2,848.50
	\$/Box	Bx/coil	per coil	No. coils	
Glass	\$350.00	2	\$700.00	9	\$6,300.00

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						*	\$12,469.50		