

## NCSX Work Approval Form (WAF)

**WBS Number: 31**

**WBS Title: Magnetic Diagnostic Systems**

**Job Number: 3101**

**Job Title: Magnetic Diagnostic Systems**

**Job Manager: Brent Stratton**

**Description:**

This effort covers the design, procurement of materials and parts, and fabrication and installation of the magnetic diagnostics for the NCSX machine. The magnetic sensors include diamagnetic loops, flux loops, saddle loops, Rogowski coils and B-coils that will provide signals to measure the magnetic flux change in the many geometries necessary to determine the magnetic field geometry using an equilibrium reconstruction code.

**Schedule:**

See Attached

**Approvals:**

_____	_____
Job Manager	Date
_____	_____
Responsible Line Manager	Date
_____	_____
Project Manager	Date
_____	_____
Engineering Department Head	Date

**NCSX June 2007 ETC  
TABLE I - DESIGN LABOR**

<b>WBS Number: 31</b>																				
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<b>Job Number: 3101</b>																				
<b>Job Title: Magnetic Diagnostic Systems</b>																				
<b>Job Manager: Brent Stratton</b>																				
<b>Description:</b>																				
<b>Included in Table II</b>																				

**NCSX June 2007 ETC  
TABLE II - Materials and Subcontracts**

<b>WBS Number: 31</b>									
<b>WBS Title: Magnetic Diagnostic Systems</b>									
<b>Job Number: 3101</b>									
<b>Job Title: Magnetic Diagnostic Systems</b>									
<b>Job Manager: Brent Stratton</b>									
<b>Materials and Subcontracts (M&amp;S)</b>									<b>Basis of Estimate</b>
<b>Description</b>	<b>Material</b>	<b>Labor</b>							
	<b>Type</b>	<b>Cost \$ (Note 1)</b>	<b>EMEM</b>	<b>EMSM</b>	<b>EMTB</b>	<b>EADM</b>	<b>EEEM</b>		
<b>New Scope Cost for Exiting T/Cs and Heater Power Leads at Port 12</b>									
<b>5 Remaining Design</b>			136						Design about 50% complete.
Distribution of wires to 2.75 ConFlat									
System Diagram									
Research Amphenol Receptical									Will modify Commercial Bud Box based upon review with tech
Impact of Cryostat									
Evaluate magnetic permeability issue									
Extend Heater Power Leads									
<b>5a Support of Procurements under Job 1204</b>			40						Vendor contacts, reqn, etc. - Labik - support of efforts by Dudek.
<b>5b Engineering Support Field/Fab Activities (Title III)</b>			25						
<b>6 Peer Review</b>			30						Based on previous experience on similar jobs
<b>7 Design Drafting</b>						30			Based on previous experience on similar jobs
Issue new drawing									
<b>8 Install and Connect T/C Feedthroughs</b>									Included in Job 1810
<b>9 Install Extra Length Wire and Connect ( Solder ) Power Feedthroughs</b>									Included in Job 1810
<b>10 Machine Twelve 2.75 CF Blanks</b>				36					Based on previous experience on similar jobs
<b>11 Rubber Seal</b>									
<b>12 Machine 6 Commercial Aluminum Boxes</b>				36					Based on previous experience on similar jobs
<b>NOTE: M&amp;S in Job 1204</b>	<b>TOTAL</b>	<b>\$28,700</b>	231	72	0	30	0		
<b>Description</b>	<b>Material</b>	<b>Labor</b>							
	<b>Type</b>	<b>Cost \$</b>	<b>EMEM</b>	<b>EMSM</b>	<b>EMTB</b>	<b>EADM</b>	<b>EEEM</b>		
<b>Existing + Added Cost for Co Wound Loops for Modular Coils</b>									
Design Protective Boxes									Work Completed
Drawings									Work Completed
Purchase SS Sheet									Work Completed
Purchase PTFE Tubing and Fiber Glass Sheath									Work Completed
Prototype									Work Completed
Formal Issue of Drawings Rev 0									Work Completed
Form 18 Protective Boxes									Work Completed
Weld end plates									Work Completed
Drawing Change , add extra slots									Work Completed
Formal Issue of Drawings Rev 1									Work Completed
Engineering Support Field/Fab Activities (Title III)									Work Completed
Fab MC co-wound loops									Work Completed
<b>TOTAL</b>		<b>\$0</b>	0	0	0	0	0		

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<b>Job Manager: Brent Stratton</b>									
Description	Material			Labor					
	Type	Cost \$	EMEM	EMSM	EMTB	EADM	EEEM		
<b>Existing + Added Cost for Co Wound Loops for 18 TF and 6 PF and 2 Solenoid Coils</b>									
Design Protective Boxes			110						TF Complete
Drawings			60						TF Complete.
Purchase SS Sheet		\$870	1						Partial.
Purchase Heat Shrink Tubing, 20 @ 100 ft		\$2,000	6						12 ordered in Dec 06 => 6 of 12 Received.
Purchase additional CoAxial cable 3500 ft		\$4,550	2						Placed order for 1900 ft
Prototype					12				TF Complete.
Formal Issue of Drawings Rev 0							0		<b>Work Completed</b>
Form 26 Protective Boxes					102				6 TF completed.
Weld end plates						18			6 TF completed.
Engineering Support Field/Fab Activities (Title III)			36						
Develop Convective Air Furnace		\$0			0				<b>Work Completed</b>
Fab TF, PF & solenoid co-wound loops					130				9 of 26 completed.
		<b>TOTAL</b>		<b>\$7,420</b>	<b>215</b>	<b>244</b>	<b>18</b>	<b>0</b>	<b>0</b>
Description	Material			Labor					
	Type	Cost \$	EMEM	EMSM	EMTB	EADM	EEEM		
<b>Existing + Added Cost for Flux Loop Junction Boxes and 20 Spacer Flux Loops and 6 Protective Boxes</b>									
Purchase Material - 2.75 ConFlat Flanges		\$900	2						Based on previous experience
Purchase Material - AL and SS Plate		\$820				2			Based on previous experience
Purchase Material - 316 SS flat head screws		\$400				2			Based on previous experience
Purchase Material - Circuit Boards RF Filtered w/TB		\$3,200						32	Based on previous experience
Install 24 JB ( 410 cables ) Act #									Included in Job 1810
Terminate 24 JB ( 410 cables )									Included in Job 1810
Anneal 2.75 Conflat Flanges					12				Based on previous experience
Engineering Support Field/Fab Activities (Title III)			120						Based on previous experience
Purchase 2000 ft 0.059 CoAx-Spacer		\$3,500	2						Based on previous experience
AutoCAD Drawings of Field Runs/Tag#/Port Assignments			112						Based on previous experience
Water Jet Machine Cu Templates		\$240				8			Based on previous experience
Install 20 Templates									Included in Job 1810
Install Spacer Flux Loops									Included in Job 1810
Twist leads									Included in Job 1810
Design Protect Box & Prepare Dwg			22						Based on previous experience
Fab 6 Prot Boxes		\$200			24				Based on previous experience
Install Prot Boxes									Included in Job 1810
Prepare Drawing of Spacer Loops							60		Based on previous experience
<b>NOTE: M&amp;S in Job 1204</b>									
		<b>TOTAL</b>		<b>\$9,260</b>	<b>258</b>	<b>36</b>	<b>12</b>	<b>60</b>	<b>32</b>

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Description	Material			Labor					
	Type	Cost \$	EMEM	EMSM	EMTB	EADM	EEEM		
<b>Existing + Added Cost for High Temperature Rogowski Coil</b>									
<b>CDR + Peer Reviews</b>			60						
<b>Preliminary Design</b>			60						
Fabricate Prototype		\$50			20				
Test Prototype		\$50		24					
Prepare for and Conduct PDR			20						
<b>Final Design</b>			60						
Purchase Spec for Winding Mandrel			40						
Trip to Vendor			16	16					
Sub contract Winding 3 Mandrels		\$15,000							
Prepare for and Conduct FDR			10						
Formal Issue of Drawings						4			
<b>Purchase Material - ARI SS Coax Cable 0.032 inch</b>		\$2,650	2						
<b>Purchase Material - SS Flex and Bendable Smooth Tube</b>		\$300	2						
<b>Purchase Material - Nextel Tape</b>		\$300	1						
<b>Purchase Material - Inconel Bar</b>		\$1,200	2						
<b>Fabricate coil clamps - 36 ( 3 Field Periods 12 ea)</b>					90				
<b>Fabricate ends</b>			4	32					
<b>Fixture to Straighten Smooth SS Tube</b>		\$30	4		32				
<b>Install Wound Coil into Protective SS Flex</b>		\$50							
Install 3 Rogowski Coils									Included in Job 1810
Weld 36 coil clamps									Included in Job 1810
Engineering Support Field/Fab Activities (Title III)			60						
<b>TOTAL</b>		<b>19,630</b>	<b>281</b>	<b>72</b>	<b>142</b>	<b>4</b>	<b>0</b>		

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Description	Material		Labor					
	Type	Cost \$	EMEM	EMSM	EMTB	EADM	EEEM	
<b>Added Cost for Voltage Loops and Protective Boxes</b>								
Drawings- Engineering Sketch of Routing			20					Based on previous experience
Drawings- Layout						16		Based on previous experience
Formal Release of Layout Drawing						4		Based on previous experience
Protective Box Design			6					Based on previous experience
Protective Box Drawing			20					Based on previous experience
Install Voltage 12 Loops on VV								Included in Job 1810
Twisted leads to Prot. Boxes								Included in Job 1810
Fab 3 Protective Boxes	316 SS by 0.048 Thk	\$120			12			Based on previous experience
Install 3 Protect. Boxes								Included in Job 1810
Engineering Support Field/Fab Activities (Title III)			6					Based on previous experience
Purchsae additional 900 ft cable	0.059 OD Inconel CoAx	\$1,600	2					
	<b>TOTAL</b>	<b>\$1,720</b>	<b>54</b>	<b>0</b>	<b>12</b>	<b>20</b>	<b>0</b>	
<b>Total</b>		<b>\$28,770</b>	<b>550</b>	<b>316</b>	<b>172</b>	<b>24</b>	<b>0</b>	

**NCSX June 2007 ETC**  
**TABLE III - Fabrication/Assembly Installation**

<b>In-house Fabrication and Assembly and Installation</b>																			
<b>Included in Table II</b>																			

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TABLE IV - Uncertainty of Estimate and Residual Risk Assessment

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**Uncertainty of the Estimate**

	<u>High</u>	<u>Medium</u>	<u>Low</u>	<u>Uncertainty Range (%)</u>	<u>Comments/Other Considerations</u>
Design Maturity	X			-5%/+10%	Exception is Rogowski => Medium - design not finalized
Design Complexity			X		Exception is Rogowski => Medium - design not finalized

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

**Residual Impacts**

Job	Risk Description	Likelihood of Occurring	Mitigation Plan	Basis of estimate	Cost Impact		Schedule Impact	
					Low	High	Low	High
High temperature Rogowski Loop damaged during installation resulting in loss of toroidal current measurement capability		5%	Triple redundancy	3 Installed - only one required.	+\$0K	+\$0K	+0.00	+0.00

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=Unlikley (40%>P>10%), VU=Very Unlikley (P<10%), NC=Non-credible (P<1%)