NCSX Work Approval Form (WAF)

WBS Number: 162
WBS Title: Coil Electrical Leads
Job Number: 1601-162
Job Title: Coil Electrical Leads
Job Manager: Paul Goranson

Description:

This WBS element consists of the design and fabrication of the coil electrical leads inside the cryostat which then connect the coils to the power supply bus or cables outside the cryostat.

Schedule:

See Attached

Approvals:

Paul Goranson
Digitally signed by Paul Goranson
DN: cn=Paul Goranson, c=US
Date: 2007.07.03 14:04:47 -04'00'

Job Manager _____ Date _____

Brad Nelson
Digitally signed by Brad Nelson
DN: cn=Brad Nelson, c=US, o=ORNL, ou=FED, email=nelsonbe@ornl.gov
Date: 2007.07.10 08:27:09 -04'00'

Responsible Line Manager _____ Date _____

Hutch Neilson
Digitally signed by Hutch Neilson
DN: CN = Hutch Neilson, C = US, O = PPPL
Date: 2007.07.10 14:01:39 -04'00'

Project Manager _____ Date _____

Mike Williams
Digitally signed by Mike Williams
DN: cn=Mike Williams, o=PPPL, ou=Engineering, email=williams@pppl.gov, c=US
Date: 2007.07.10 14:13:16 -04'00'

Engineering Department Head _____ Date _____

NCSX June 2007 ETC
TABLE I - DESIGN LABOR

WBS Number: 162
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Description:
This effort covers all Title I, II, and III engineering for the LN2 distribution system inside the cryostat, which includes all the necessary manifolding and connections to interface with the ex-cryostat LN2 supply system. This system will be fabricated in-house by PPPL. All Title III engr associated with installation is included in WBS 7.

Task ID	Multiplier	Unit	Number of Units	Hours	HOURS ORNL EM	ORNL	DSN	ORNDL	RM	EMEM	EMSM	EMSB	EMTB	EAEM	EASM	EEEM	EESM	EESB	EETB	ECEM	ECSB	ECTB	Basis of Estimate
Title I an II Design																							
Pro-E models (avg)	8	hrs/model	50	400	400																		See Worksheet below - based on recent experience at MDL
assy dwgs	16	hrs/dwg	15	240	240																		See Worksheet below - based on recent experience at MDL
Detail drawings	8	hrs/dwg	40	320	320																		See Worksheet below - based on recent experience at MDL
installation dwg	16	hrs/dwg	29	464	464																		See Worksheet below - based on recent experience at MDL
cooling schematic	0	hrs/dwg	1	0	0																		See Worksheet below - based on recent experience at MDL
electrical schematic	8	hrs/dwg	14	112	112																		See Worksheet below - based on recent experience at MDL
I&C schematic	8	hrs/dwg	0	0	0																		See Worksheet below - based on recent experience at MDL
stress analysis	0	hrs/calc	0	0	0																		See Worksheet below - based on recent experience at MDL
thermal analysis	24	hrs/calc	1	24	24																		See Worksheet below - based on recent experience at MDL
special analysis (electromagnetics)	40	hrs/calc	1	40	40																		See Worksheet below - based on recent experience at MDL
Procuremnt Specifications	40	hrs/spec	1	40	40					0													See Worksheet below - based on recent experience at MDL
preliminary and final design reviews	40	hrs/rev	1	40	40																		See Worksheet below - based on recent experience at MDL
meetings/reporting/presentations	10%	% of tot hrs		168	168																		See Worksheet below - based on recent experience at MDL
Subtotal Title I & II Design				***1848***	***1848***	***0***	***0***	***0***	***0***		***0***	***0***	***0***	***0***	***0***	***0***		***0***	***0***	***0***	***0***	***0***	
Title III																							
vendor inspection & oversight	8	hrs per	1	8	8																		
Disposition of deviation requests and non-conformances	0.5	hrs/wk	20	10	10																		Based on recent experience on NCSX
In-House fab/assy oversight & inspection	2	hrs/wk	4	8											8								
As-built drawings	1	hrs/dwg	84	84	84																		Based on recent experience on NCSX
Subtotal Title III Design				***110***	***102***	***0***	***0***	***0***	***0***		***0***	***0***	***0***	***8***	***0***	***0***		***0***	***0***	***0***	***0***	***0***	

Notes and worksheets

PF Coil leads

	coils at 10, 70, 130, 190, 250, 310 degrees	coils at 30, 90, 150, 210, 270, 330 degrees	coils at 50, 110, 170, 230, 290, 350 degrees	PF1-2	PF3	PF4	PF5	PF6	coils at 0, 120, 240, degrees, top and bottom	coils at 60, 180, 300 degrees Top and bottom	Outer perimeter coils	coil 1 at 10, 70, 130, 190, 250, 310 degrees	coil 2 at 30, 90, 150, 210, 270, 330 degrees	coil 3 at 50, 110, 170, 230, 290, 350 degrees	thermal transition box	total	
Pro-E models	6	6	6	1	1	1	1	1	3	3	2	6	6	6	1	50	leads modeled to create drawings, reserve space in assembly
assy dwgs	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	one assembly for each circuit
Detail drawings	3	3	3	2	2	2	2	2	3	3	3	3	3	3	3	40	drawings for lead length, mounting details
installation dwg	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	29	one installation dwg for each cable
cooling schematic																1	one cooling schematic for all leads
electrical schematic	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	14	one schematic for each circuit
I&C schematic																	part of WBS 163
stress analysis																	
thermal analysis																1	one analysis to check temp rise, cooling
special analysis																1	one analysis for field error determination
procurement specifications																1	one specification for leads, all carry the same current, will have tl
preliminary and final design reviews																1	one review for all coil leads
meetings/reporting/presentations																10%	

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Description:
This effort covers all coil leads that connect the coil terminals to the buswork at the boundary of the cryostat. The lead cables are all the same except for length, and will be procured from a qualified vendor. All installation will be performed as pa

Assumptions:

			Basis of Estimate
outside engr rate =	120	$ per hour	Based on recent experiences on NCSX and UT work being done at MDL
outside fab rate =	60	$ per hour	Based on recent experiences on NCSX and UT work being done at MDL
outside inspection/technician rate =	80	$ per hour	Based on recent experiences on NCSX and UT work being done at MDL

TOTAL MATERIAL COST = $86,687

Purchased parts:

set of cables	$0		
misc attachment hardware	$11,091	@10$/ft	
thermal transition box material	$0		Based on recent experiences on NCSX and UT work being done at MDL
subtotal, purchased parts	$11,091		

Lead bundles consist of six, 250 MCM cable with teflon sleeve. Lead ends are cooled by bleed liquid nitrogen supplied by the coil coolant header (WBS 161)
Leads connect from coil terminals to buswork at bottom of machine.
Each coil is connected separately except PF1 and PF2, which are connected in series within the central solenoid assembly

Purchased materials for in-house fabrication and sub-assembly

None required	$0	
subtotal purchased materials	0	

Worksheet, TF Coils:

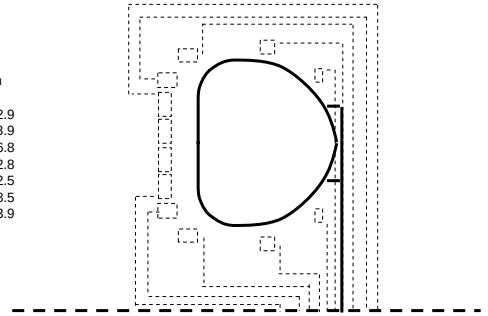
Lead cost, TF Coils

Terminations,assembly	$200	ea	Based on recent experiences on NCSX and UT work being done at MDL
Cable with teflon insulation, reinforced teflon outer jacket	$50	per foot	Based on recent experiences on NCSX and UT work being done at MDL
Total number of cables	18		
Total length of cables	277		
Total cable cost	**$17,452**		

Geometry

radius of vertical runs	12	ft
height of upper terminals	11	ft
height of lower terminals	7	ft

Lengths	terminal radius (m)	height from floor (ft)	cable length (ft)
coils at 10, 130, 250 degrees	3.00	11.00	12.9
coils at 70, 190, 310 degrees	3.00	7.00	8.9
coils at 30, 150, 270 degrees	3.00	11.00	16.8
coils at 90, 210, 330 degrees	3.00	7.00	12.8
coils at 50, 170, 290 degrees	3.00	11.00	22.5
coils at 110, 230, 350 degrees	3.00	7.00	18.5
Subtotals			73.9
Total length	222	ft	
25% extra for bends, offsets	55		
Total procured length	**277**	ft	
Avg length per cable	15	ft	



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Worksheet, PF Coils:

Lead cost, PF Coils

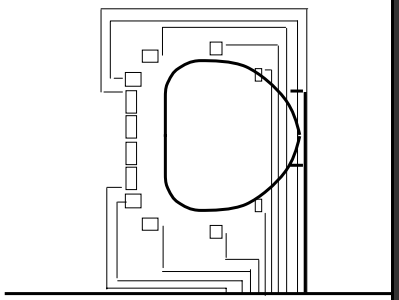
Terminations,assembly	$200 ea	
Cable with teflon insulation, reinforced teflon outer jacket	$50 per foot	Based on recent experiences on NCSX and UT work being done at MDL
Total number of cables	10	Based on recent experiences on NCSX and UT work being done at MDL
Total length of cables	181	
Total cable cost	**$11,052**	

Geometry

radius of vertical runs	10 ft
height of upper runs	12 ft
height of connection to buswork	0 ft

Lengths	terminal radius (m)	height from midplane (m)	top length (ft)	bottom length (ft)
TF Coils				
PF1, PF2, connected in series as assy	0.00	1.30	29.7	14.3
PF3	0.00	1.30	29.7	14.3
PF4	0.69	1.60	26.5	13.0
PF5	2.23	1.50	7.6	7.6
PF6	2.80	1.00	4.1	4.1
External Trim Coils				
Mod Coils				
Subtotals			97.7	53.2

Total length	151 ft
20% extra for bends, toroidal offsets	30
Total procured length	**181** ft
Avg length per cable	18 ft



Worksheet, Error field correction coil leads:

Lead cost, Error field coils

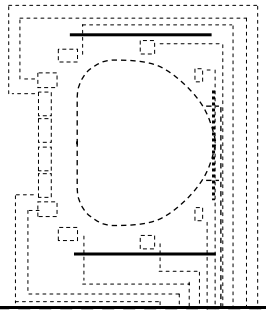
Terminations,assembly	$200 ea	Based on recent experiences on NCSX and UT work being done at MDL
Cable with teflon insulation, reinforced teflon outer jacket	$50 per foot	Based on recent experiences on NCSX and UT work being done at MDL
Total number of cables	2	
Total length of cables	104	
Total cable cost	**$5,620**	

Geometry

radius of vertical runs	12 ft
height of upper terminals	12 ft
height of lower terminals	6 ft

Lengths	terminal radius (m)	height from floor (ft)	cable length (ft)
coils at 0 degrees, top and bottom	3.00	12.00	13.9
Subtotals			13.9

Total length	84 ft
25% extra for bends, offsets	21
Total procured length	**104** ft
Avg length per cable	52 ft



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Worksheet, Mod coils:

Lead cost for modular coils

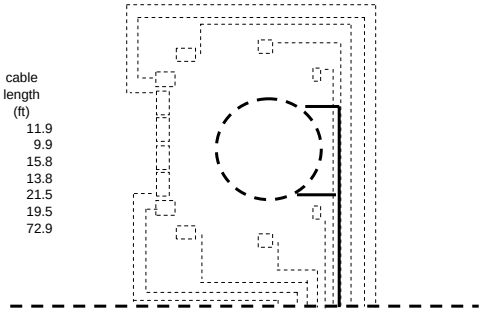
Terminations,assembly	$200 ea	**Based on recent experiences on NCSX and UT work being done at MDL**
Cable with teflon insulation, reinforced teflon outer jacket	$50 per foot	**Based on recent experiences on NCSX and UT work being done at MDL**
Total number of cables	36	
Total length of cables	547	
Total cable cost	**$34,529**	

Geometry

radius of vertical runs	12 ft
height of upper terminals	10 ft
height of lower terminals	8 ft

Lengths	terminal radius (m)	height from floor (ft)	cable length (ft)
coils at 10, 130, 250 degrees	3.00	10.00	11.9
coils at 70, 190, 310 degrees	3.00	8.00	9.9
coils at 30, 150, 270 degrees	3.00	10.00	15.8
coils at 90, 210, 330 degrees	3.00	8.00	13.8
coils at 50, 170, 290 degrees	3.00	10.00	21.5
coils at 110, 230, 350 degrees	3.00	8.00	19.5
Subtotals			72.9

Total length	219 ft
25% extra for bends, offsets	55
Total procured length	**547** ft
Avg length per cable	15 ft



Worksheet, lead thermal transition box

66 leads, 11 to a box	size (in)	number reqd	cost ea		total	
sheet material, foil backed insul. foam	1 x 48 x 96	5	25	$	125	**Based on recent experiences on NCSX and UT work being done at MDL**
end seals	1" tube x 6"	22	20	$	440	**Based on recent experiences on NCSX and UT work being done at MDL**
cryo epoxy		.5 lb	28	$	14	**Based on recent experiences on NCSX and UT work being done at MDL**
misc mount hardware, ss base frame				$	500	**Based on recent experiences on NCSX and UT work being done at MDL**
foam caulk	16 oz	4	4	$	16	**Based on recent experiences on NCSX and UT work being done at MDL**
acryic sheet window	3/8" x 12 x 24	1	62	$	62	**Based on recent experiences on NCSX and UT work being done at MDL**
assembly	40 hr each=	40				**Based on recent experiences on NCSX and UT work being done at MDL**
				$	1,157	each
number required for test floor					6	
			Total hrs for fab		240	
			Total M&S	**$**	**6,943**	

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TABLE III - Fabrication and Assembly

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Fabrication and Assembly

No local fab or assembly is anticipated for the Coil leads. Installation is part of WBS 7.

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TABLE IV - Uncertainty of Estimate and Residual Risk Assessment

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Uncertainty of the Estimate

	High	Medium	Low	Uncertainty Range (%)		Comments/Other Considerations
Design Maturity	X			-5%/+10%	Design well established based on previous devices	
Design Complexity			X		Standard Components	
Other Comments:						

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 Low	Cost Impact High	Schedule Impact Low	Schedule Impact High
NONE								

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 reponsible 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 Unlikely (P<10%), NC=Non-credible (P<1%)