NCSX Work Approval Form (WAF)

WBS Number: 161

WBS Title: LN2 Distribution System

Job Number: 1601-161

Job Title: LN2 Distribution System

Job Manager: Paul Goranson

Description:

This element covers the electrical leads within the cryostat, serving all the coils: the TF (WBS 131), PF (WBS 132), External Trim (WBS 133), and Modular (WBS 14) Coils. Work includes engineering design, procurement, and fabrication of leads and associated supports. Work in this WBS ends with the delivery of components to machine assembly operations.

Schedule:

See Attached

Approvals:

Paul Goranson
Digitally signed by Paul Goranson
DN: cn=Paul Goranson, c=US
Date: 2007.07.03 14:04:19 -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 08:26:03 -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 14:01:53 -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 14:13:41 -04'00'

Engineering Department Head _____ Date _____

NCSX June 2007 ETC
TABLE I - DESIGN LABOR

WBS Number: 161
WBS Title: LN2 Distribution System
Job Number: 1601-161
Job Title: LN2 Distribution System
Job Manager: Paul Goranson

Description:
This element covers the design of the electrical leads within the cryostat, serving all the coils: the TF (WBS 131), PF (WBS 132), External Trim (WBS 133), and Modular (WBS 14) Coils.

Task ID	Multiplier	Unit	Number of Units	Hours	HOURS ORNL EIM	ORNL DSN	ORNL RM	EMEM	EMSM	EMSB	EMTB	EAEM	EASB	Basis of Estimate
Title I an II Design														
Pro-E models (avg)	4	hrs/model	40	160	160									See Worksheet below - based on recent experience at MDL
assy dwgs	8	hrs/dwg	11	88	88									See Worksheet below - based on recent experience at MDL
Detail drawings	4	hrs/dwg	6	24	24									See Worksheet below - based on recent experience at MDL
installation dwg	8	hrs/dwg	11	88	88									See Worksheet below - based on recent experience at MDL
cooling schematic	20	hrs/dwg	1	20	20									See Worksheet below - based on recent experience at MDL
electrical schematic	0	hrs/dwg	1	0	0									See Worksheet below - based on recent experience at MDL
I&C schematic	20	hrs/dwg	1	20	20									See Worksheet below - based on recent experience at MDL
stress analysis	40	hrs/calc	1	40	40									See Worksheet below - based on recent experience at MDL
thermal analysis	40	hrs/calc	1	40	40									See Worksheet below - based on recent experience at MDL
special analysis (electromagnetics)	160	hrs/calc	0	0	0									See Worksheet below - based on recent experience at MDL
fab specifications	160	hrs/spec	2	320	320									See Worksheet below - based on recent experience at MDL
preliminary and final design reviews	80	hrs/rev	2	160	160									See Worksheet below - based on recent experience at MDL
meetings/reporting/presentations	10%	% of tot hrs		96	96									See Worksheet below - based on recent experience at MDL
Subtotal Title I & II Design				***1056***	***1056***	***0***		***0***	***0***	***0***	***0***	***0***	***0***	
Title III														
Disposition of deviation requests and non-conformances	1	hrs per	38	38				38	0	0	0	0	0	Based on recent experience on NCSX
As-built drawings	2	# dwgs	29	58		58	0	0	0	0	0	0	0	Based on recent experience on NCSX
Procurement coordination				80		0	0	40	40	0	0	0	0	Based on recent experience on NCSX
Subtotal Title III Design				***176***	***0***	***58***	***0***	***78***	***40***	***0***	***0***	***0***	***0***	
				176										
			1290.6		58.6									

NCSX June 2007 ETC
TABLE I - DESIGN LABOR

WBS Number: 161
WBS Title: LN2 Distribution System
Job Number: 1601-161
Job Title: LN2 Distribution System
Job Manager: Paul Goranson

Notes and worksheets

LN2 distribution system

	total	Vessel Torus,	Port Extensions	NBI duct	Manifolds	Headers	
Pro-E models	33	10	13	2	6	2	models for each type of tube, manifold, and header
assy dwgs	5	1	1	1	1	1	
Detail drawings	6	0	0	0	4	2	drawings of each manifold and header
installation dwg	4	1	1	1	1		on drawing per type of part
cooling schematic	0						
electrical schematic	0						
I&C schematic	0						
stress analysis	1						
thermal analysis	1	1					one analysis for all cooling lines
special analysis	0						
procurement specifications	1						one procurement spec for the tubing, piping and fittings
preliminary and final design reviews	1						one review for all the plumbing
meetings/reporting/presentations	15%						

Flow Control System	total	
Pro-E models	6	elements added to piping system
assy dwgs	6	
Detail drawings	0	
installation dwg	6	
cooling schematic	1	block flow diagram
electrical schematic	1	actuator electrical schematic, if applicable
I&C schematic	0	
stress analysis	0	
thermal analysis	0	
special analysis	0	
procurement specifications	1	one procurement specification for all flow control elements
preliminary and final design reviews	0	reviews covered under WBS 191
meetings/reporting/presentations	10%	

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TABLE I - DESIGN LABOR

WBS Number: 161
WBS Title: LN2 Distribution System
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Local I&C	
Pro-E models	1
assy dwgs	0
Detail drawings	0
installation dwg	1
cooling schematic	0
electrical schematic	0
I&C schematic	1
stress analysis	0
thermal analysis	0
special analysis	0
procurement specifications	0
preliminary and final design reviews	1
meetings/reporting/presentations	10%

Notes:
1. LN2 distribution system instrumentation consists of a single thermocouple placed on each return header inside cryostat
2. There will be a single supply and return header for each field period which supplies the TF coils and the upper and lower PF coils
3. Reviews and procurement specs for T/C are covered as part of WBS 171

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TABLE II- Materials and Subcontracts

WBS Number: 161
WBS Title: LN2 Distribution System
Job Number: 1601-161
Job Title: LN2 Distribution System
Job Manager: Paul Goranson

Materials and Supplies

Description:
This effort covers procurement of materials for the LN2 distribution system by fixed price subcontract.

Basis of Estimate

Assumptions:

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**

Purchased parts:

coolant line pigtails from coils to manifolds	$18,480	see notes below	**See Worksheet Below**
Insulating Jumper hoses	$4,320		**See Worksheet Below**
Manifolds for cooling lines	$6,612		**See Worksheet Below**
valves	$6,000	see notes below	**See Worksheet Below**
other hardware	$23,200		**See Worksheet Below**
Thermocouples	$0	included in job 1431 for the modular coil fabrication	
subtotal, purchased parts	**$58,612**		

Worksheet:

coolant line pigtails from coils to manifolds

Average length of pigtail 3 ft

	Total	TF	Modular	PF1	PF2	PF3	PF4	PF5	PF6
No. of coils	48	18	18	**2**	2	2	**2**	**2**	**2**
circuits per coil at header		1	8	**0.5**	0.5	0.5	**0.5**	**0.5**	0.5
total circuits	168	18	144	1	1	1	1	1	1

Total number of pigtails	336	supply and return per circuit	
Cost per pigtail, with fittings	$55		
Total cost of pigtails	$18,480		**Based on recent purchases for NCSX and UT at MDL**
Number of MC coil insulating break jumper hoses and end fittings	144		
cost per jumper	30		**Based on recent purchases for NCSX and UT at MDL**
total cost of jumpers	$ 4,320		
total cost of all lines			

Manifolds for cooling lines

Assume 1 pair of 1.5 inch manifolds for each field period, one above and one below the midplane inside the PF5 coil
Each manifold will have 1/3 of the required cooling connections plus 25% spare
The manifolds will connect via vertical pipes to the supply system below the cryostat

avg toroidal perimeter of field period	16	ft	
avg vertical height of connection lines	9	ft	
no of header pairs	3		
cost of tubing	$15	per foot, 316 SSt	**Based on recent purchases for NCSX and UT at MDL**
cost per field period	$2,232		
total number of coolant connections, all headers	840		
cost per connection	$5		
cost of nipples for all manifolds	$4,200		
welding consumables	$200	total	
no. connections for supply piping	6	2 connections per manifold	
cost per connection	$30		
cost for supply piping connections	$180		
total matl cost for manifolds	$6,612		

Flow control hardware

no. of circuits	24		
Valves	$250	ea	**Based on recent purchases for NCSX and UT at MDL**
no.of valves	24	one for each pf and tf coil circuit at manifold	
Total cost for valves	$6,000		
flow control orifice at manifold	$50	ea	**Based on recent purchases for NCSX and UT at MDL**
no of orifice units	144	one for each MC coil circuit	
Total cost for orifice	$7,200		
Other misc items	$10,000		**Based on recent purchases for NCSX and UT at MDL**
total hardware	$23,200		

Thermocouples

Number	0	ea	**Included in Job 1431**
Thermocouple cost each, with connector	68	$ each	**Based on recent purchases for NCSX and UT at MDL**
total for thermocouples	$0		

TOTAL

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TABLE III - Fabrication and Assembly

WBS Number: 161
WBS Title: LN2 Distribution System
Job Number: 1601-161
Job Title: LN2 Distribution System
Job Manager: Paul Goranson

Fabrication and Assembly

Description:
This effort covers all the assembly time to put the cooling line tracing on the exterior of the vessel and ports, and to build the coolant manifolds

					Labor category			**Basis of Estimate**
	multiplier	**unit**	**no.**	**hours**	EMEM hrs	EMTB hrs	EADM hrs	
Fab operations summary								
Manifold Cooling Lines	615	hrs/lot	1	615	123	492	0	**See Worksheet Below**
subtotal	**615**			***615***	***123***	***492***	***0***	
Assembly operations summary					hrs	hrs		**None - Part of Machine Assembly Jobs**
subtotal	0			0	*0*	*0*	*0*	

Worksheets

coolant line pigtails from coils to manifolds

Average length of pigtail 3 ft

	Total	TF	**Modular**	PF1	PF2	PF3	PF4	PF5	PF6
No. of coils	38	18	18	**2**	2	2	**2**	**2**	**2**
circuits per coil at header		1	8	0.5	0.5	0.5	0.5	0.5	0.5
total circuits	168	18	144	1	1	1	1	1	1
Total number of pigtails	336	supply and return per circuit							

Manifolds for cooling lines

Assume 1 pair of 1.5 inch manifolds for each field period, one above and one below the midplane inside the PF5 coil
Each manifold will have 1/3 of the required cooling connections plus 25% spare
The manifolds will connect via vertical pipes to the supply system below the cryostat

avg toroidal perimeter of field period	16	ft	
avg vertical height of connection lines	9	ft	
no of header pairs	3		
cost of tubing	$15	per foot, 316 SSt	**Based on recent purchases for NCSX and UT at MDL**
cost per field period	$2,232		
total number of coolant connections, all headers	840		
hours to weld each connection	0.5	hr per connection	**Based on recent experience at MDL**
shifts to form manifold tube	0.5	per manifold pair	**Based on recent experience at MDL**
crew size for forming	2		**Based on recent experience at MDL**
hours to cut vertical pipes	2	hrs per pipe	**Based on recent experience at MDL**
hours to weld vertical pipes to header	2	hrs per pipe	**Based on recent experience at MDL**
total shifts for manifolds	62		**Based on recent experience at MDL**
tech hours for manifolds	492	hours	**Based on recent experience at MDL**
technical oversight, inspection	123	hrs	**Based on recent experience at MDL**
total hours for manifolds	**615**	**hrs**	

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TABLE IV - Uncertainty of Estimate and Residual Risk Assessment

WBS Number: 161
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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%)