

## NCSX Fabrication Project Cost and Schedule Estimating Form

### WBS 161 LN2 Distribution System Inside Cryostat

#### Labor

Activity Title	Manhours	FY2003 \$\$	Labor Type	Start Date Month/Yr	End Date Month/Yr	Comments
<b>Preliminary Design (Title I)</b>						
( 33% of design schedule)	80		<i>EAEM</i>	Dec-05	Jan-06	PPPL Engineer
	0		<i>EADM</i>	Dec-05	Jan-06	PPPL Designer
	251		<i>ORNL Eng</i>	Dec-05	Jan-06	Composite of ORNL Engineer / Designer
	0		<i>ORNL Phys.</i>	Dec-05	Jan-06	Composite of ORNL Physics / scientific
	0		<i>PPPL Phys.</i>	Dec-05	Jan-06	PPPL Physics/scientific
<b>Final Design (Title II)</b>						
( 67% of design schedule)	160		<i>EAEM</i>	Jan-06	Apr-06	PPPL Engineer
	0		<i>EADM</i>	Jan-06	Apr-06	PPPL Designer
	503		<i>ORNL Eng</i>	Jan-06	Apr-06	Composite of ORNL Engineer / Designer
	0		<i>ORNL Phys.</i>	Jan-06	Apr-06	Composite of ORNL Physicist
	0		<i>PPPL Phys.</i>	Jan-06	Apr-06	PPPL Physics/scientific
<b>Lab R&amp;D labor</b>						
	0		<i>EAEM</i>	Dec-05	Jan-06	PPPL Engineer
	0		<i>EADM</i>	Dec-05	Jan-06	PPPL Designer
	0		<i>ORNL Eng</i>	Dec-05	Jan-06	Composite of ORNL Engineer / Designer
	0		<i>EASM</i>	Dec-05	Jan-06	PPPL monthly support
	0		<i>EMTB</i>	Dec-05	Jan-06	PPPL Technician
<b>Lab Fab/Assembly/Installation (Title III)</b>						
	8		<i>EAEM</i>	Apr-06	Jan-07	PPPL Engineer
	0		<i>EADM</i>	Apr-06	Jan-07	PPPL Designer
	86		<i>ORNL Eng</i>	Apr-06	Jan-07	Composite of ORNL Engineer / Designer
	71		<i>EASM</i>	Apr-06	Jan-07	PPPL monthly support
	284		<i>EMTB</i>	Apr-06	Jan-07	PPPL Technician

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		<i>Manhours per fiscal year by labor category</i>						
Level of Effort		FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	TOTAL
PPPL Engineer	<i>EAEM</i>	0	0	0	245	3	0	248
PPPL Designer	<i>EADM</i>	0	0	0	0	0	0	0
Composite of ORNL Engineer / Designer	<i>ORNL Eng</i>	0	0	0	811	30	0	841
PPPL monthly support	<i>EASM</i>	0	0	0	46	25	0	71
PPPL Technician	<i>EMTB</i>	0	0	0	186	98	0	284
Composite of ORNL Physics / scientific	<i>ORNL Phy</i>	0	0	0	0	0	0	0
PPPL Physics/scientific	<i>PPPL Phy</i>	0	0	0	0	0	0	0

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### WBS 161 LN2 Distribution System Inside Cryostat

#### M&S Costs

Activity Title	FY2003 \$\$	Comment
<b>Manufacturing Development (R&amp;D)</b>		
Purchased Design Services	\$0	
Procured Hardware/Material	\$0	
Profit	\$0	included in hardware estimate
<i>total, manf/dev (R&amp;D)</i>	\$0	w/o G&A
<b>Procured Hardware/Material</b>		
tubing, manifolds, headers	\$52,945	
Profit	\$0	included in hardware estimate
<i>total, procured hdwe/matl.</i>	\$52,945	w/o G&A
<b>Purchased Design Services</b>	\$0	no purchased services anticipated
<b>Procured Installation/Assembly Costs</b>	\$0	All installation and assembly costs are included in WBS 7

#### Other Costs

Activity Title	FY2003 \$\$	Comment
Travel	\$0	no trips are anticipated for this WBS

## NCSX Fabrication Project Cost and Schedule Estimating Form

### WBS 161 LN2 Distribution System Inside Cryostat

#### Summary Costs

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Activity Title	Manhours	FY2003 \$\$	Comment
<b>Labor</b>			
PPPL Effort	603	\$65,715	<i>Assumed rates:</i> <i>EAEM</i> 153 \$/hr <i>EADM</i> 100 \$/hr <i>ORNL Eng</i> 130 \$/hr <i>EASM</i> 100 \$/hr <i>EMTB</i> 73 \$/hr PPPL Phys 141 \$/hr ORNL Phys 160 \$/hr
ORNL effort	841	\$109,304	
subtotal, labor	1,443	\$175,019	
<b>M&amp;S, Other</b>			
Manufacturing Development (R&D)		\$0	
Procured Hardware/Material		\$52,945	
Purchased Design Services		\$0	
Procured Installation/Assembly Costs		\$0	
Travel		\$0	
subtotal, M&S		\$52,945	
<b>G&amp;A</b>		\$13,236	25% on all purchased materials, subcontracts, travel
<b>Subtotal without contingency</b>		\$241,200	
<b>Contingency</b>		\$67,536	28% Overall on this WBS
<b>Total cost</b>		\$308,736	

# NCSX Fabrication Project Cost and Schedule

## WBS 161 LN2 Distribution System Inside Cryostat

### In-house Fabrication and Assembly

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**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

					<b>Labor category</b>												
					total	EAEM		EASM, EMSM		EMTB		EADM					
					fraction	fract.	hrs	fract.	hrs	fract.	hrs	fract.	hrs				
<b>Fab operations summary</b>	multiplier	unit	no.	hours													
	355	hrs/lot	1	355	1.00	0.00	0	0.20	71	0.80	284	0.00	0				
	0	hrs/line	1	0	0.00	0.00	0	0.00	0	0.00	0	0.00	0				
	0	hrs / coil	1	0	0.00	0.00	0	0.00	0	0.00	0	0.00	0				
<i>subtotal</i>	355			355			0		71		284		0				
<b>Assembly operations summary</b>									total	EAEM		EASM, EMSM		EMTB		EADM	
					fraction	fract.	hrs	fract.	hrs	fract.	hrs	fract.	hrs				
	0	hr/lot	1	0	0.00	0.00	0	0.00	0	0.00	0	0.00	0				
	0	hr/lot	1	0	0.00	0.00	0	0.00	0	0.00	0	0.00	0				
	0	hr/coil	1	0	0.00	0.00	0	0.00	0	0.00	0	0.00	0				
	0	hours	1	0	0.00	0.00	0		0	0.00	0	0.00	0				
<i>subtotal</i>	0			0			0		0		0		0				

**WBS 161 LN2 Distribution System Inside Cryostat**

**Materials and Subcontracts (M&S)**

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**Description:**

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

**Assumptions:**

outside engr rate = 120 \$ per hour  
 outside fab rate = 60 \$ per hour  
 outside inspection/technician rate = 80 \$ per hour

**Purchased parts:**

coolant line pigtails from coils to manifolds \$2,240 see notes below  
 Manifolds for cooling lines \$6,105  
 valves \$14,000 see notes below  
 other hardware \$29,600  
 Thermocouples \$1,000  
*subtotal, purchased parts* **\$52,945**

**Worksheet:**

**coolant line pigtails from coils to manifolds**

Average length of pigtail		3 ft				
	Total	TF	Modular	PF1	PF2	PF3
No. of coils	38	18	18	2	2	2
circuits per coil at header		1	2	1	1	1
total circuits	56	18	36	2	2	2
Total number of pigtails	112	supply and return per circuit				
Cost per pigtail, with fittings	\$20					
Total cost of pigtails	\$2,240					

**Manifolds for cooling lines**

Assume 2 pairs of 2 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	6
cost of tubing	\$15 per foot, 316 SS1
cost per field period	\$4,465
total number of coolant connections, all headers	280
cost per connection	\$5
cost of nipples for all manifolds	\$1,400
welding consumables	\$200 total
no. connections for supply piping	12 2 connections per manifold pair
cost per connection	\$20
cost for supply piping connections	\$240
total matl cost for manifolds	\$6,105

**Flow control hardware**

no. of circuits	56
Valves	\$250 ea
no. of valves	56 one for each coil circuit
Total cost for valves	\$14,000
Pressure gages	\$100 ea
no of gages	56 one for each coil circuit
Total cost for gages	\$5,600

## NCSX Fabrication Project Cost and Schedule

### WBS 161 LN2 Distribution System Inside Cryostat

#### Engineering, Title I, II and III

**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.

	multiplier	unit	no.	hours	Labor category										
					total fraction	EAEM		EADM		ORNL Eng		ORNL Physics		PPPL Physics	
						fract.	hrs	fract.	hrs	fract.	hrs	fract.	hrs	fract.	hrs
<b>Title I, II design</b>															
Pro-E models (avg)	4	hrs/model	38	152	1.00	0.00	0	0.00	0	1.00	152	0.00	0	0.00	0
assy dwgs	8	hrs/dwg	10	80	1.00	0.00	0	0.00	0	1.00	80	0.00	0	0.00	0
Detail drawings	4	hrs/dwg	6	24	1.00	0.00	0	0.00	0	1.00	24	0.00	0	0.00	0
installation dwg	8	hrs/dwg	11	88	1.00	0.00	0	0.00	0	1.00	88	0.00	0	0.00	0
cooling schematic	20	hrs/dwg	1	20	1.00	0.00	0	0.00	0	1.00	20	0.00	0	0.00	0
electrical schematic	0	hrs/dwg	1	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	0.00	0
I&C schematic	20	hrs/dwg	1	20	1.00	0.00	0	0.00	0	1.00	20	0.00	0	0.00	0
stress analysis	40	hrs/calc	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	0.00	0
thermal analysis	40	hrs/calc	1	40	1.00	0.00	0	0.00	0	1.00	40	0.00	0	0.00	0
special analysis (electromagnetics)	160	hrs/calc	0	0	1.00	0.00	0	0.00	0	0.00	0	1.00	0	0.00	0
procurement/fab specifications	160	hrs/spec	2	320	1.00	0.75	240	0.00	0	0.25	80	0.00	0	0.00	0
preliminary and final design reviews	80	hrs/rev	2	160	1.00	0.00	0	0.00	0	1.00	160	0.00	0	0.00	0
meetings/reporting/presentations	10%	% of tot	904	90	1.00	0.00	0	0.00	0	1.00	90	0.00	0	0.00	0
<i>subtotal</i>				994			240		0		754		0		0
<b>Title III</b>															
vendor oversight, inspection	0	hrs/wk	12	0	1.00	0.50	0	0.00	0	0.00	0	0.50	0		
Disposition of deviation requests and non-conformances	1	hrs/wk	38	38	1.00	0.20	8	0.00	0	0.00	0	0.80	30		
As-built drawings	2	hrs/dwg	28	56	1.00	0.00	0	0.00	0	0.00	0	1.00	56		
<i>subtotal</i>				94			8		0		0		86		

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#### Engineering, Title I, II and III

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Schedule assumptions	start	duration (weeks)	end
Title I Design	Dec-05	6	Jan-06
Title II Design	Jan-06	12	Apr-06
Procurement	Apr-06	12	Jul-06
In-house fab / sub-assy	Jul-06	0	Jul-06
Installation / final assembly	Jul-06	26	Jan-07

#### Notes and worksheets

##### LN2 distribution system

	total	vessel forus,	port extensions	NBI duct	manifolds	headers	
Pro-E models	31	10	13	2	6	2	2 models for each type of tube, manifold, and header
assy dwgs	4	1	1	1	1	1	
Detail drawings	6	0	0	0	6	2	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	0						
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