

NCSX Fabrication Project Cost and Schedule Estimating Form

WBS 123 Vacuum Vessel Heating and Cooling system

Labor

Activity Title	Manhours	FY2003 \$\$	Labor Type	Start Date Month/Yr	End Date Month/Yr	Comments
Preliminary Design (Title I)						
(33% of design schedule)	10		<i>EAEM</i>	Dec-05	Jan-06	PPPL Engineer
	0		<i>EADM</i>	Dec-05	Jan-06	PPPL Designer
	97		<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
Final Design (Title II)						
(67% of design schedule)	20		<i>EAEM</i>	Jan-06	Apr-06	PPPL Engineer
	0		<i>EADM</i>	Jan-06	Apr-06	PPPL Designer
	194		<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
Lab R&D labor						
	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
Lab Fab/Assembly/Installation (Title III)						
	8		<i>EAEM</i>	Apr-06	Jan-07	PPPL Engineer
	0		<i>EADM</i>	Apr-06	Jan-07	PPPL Designer
	48		<i>ORNL Eng</i>	Apr-06	Jan-07	Composite of ORNL Engineer / Designer
	34		<i>EASM</i>	Apr-06	Jan-07	PPPL monthly support
	137		<i>EMTB</i>	Apr-06	Jan-07	PPPL Technician

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Labor

Manhours per fiscal year by labor category

Level of Effort		FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	TOTAL
PPPL Engineer	<i>EAEM</i>	0	0	0	35	3	0	38
PPPL Designer	<i>EADM</i>	0	0	0	0	0	0	0
Composite of ORNL Engineer / Designer	<i>ORNL Eng</i>	0	0	0	323	17	0	340
PPPL monthly support	<i>EASM</i>	0	0	0	22	12	0	34
PPPL Technician	<i>EMTB</i>	0	0	0	90	47	0	137
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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M&S Costs

Activity Title	FY2003 \$\$	Comment
Manufacturing Development (R&D)		
Purchased Design Services	\$0	
Procured Hardware/Material	\$0	
Profit	\$0	included in hardware estimate
<i>total, manf/dev (R&D)</i>	\$0	w/o G&A
Procured Hardware/Material		
tubing, manifolds, headers	\$67,799	
Profit	\$0	included in hardware estimate
<i>total, procured hdwe/matl.</i>	\$67,799	w/o G&A
Purchased Design Services	\$0	no purchased services anticipated
Procured Installation/Assembly Costs	\$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

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WBS 123 Vacuum Vessel Heating and Cooling system

Summary Costs

Activity Title	Manhours	FY2003 \$\$	Comment
Labor			
PPPL Effort	209	\$19,179	<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 <i>PPPL Phys</i> 141 \$/hr <i>ORNL Phys</i> 160 \$/hr
ORNL effort	340	\$44,148	
subtotal, labor	548	\$63,327	
M&S, Other			
Manufacturing Development (R&D)		\$0	
Procured Hardware/Material		\$67,799	
Purchased Design Services		\$0	
Procured Installation/Assembly Costs		\$0	
Travel		\$0	
subtotal, M&S		\$67,799	
G&A		\$16,950	25% on all purchased materials, subcontracts, travel
Subtotal without contingency		\$148,075	
Contingency		\$47,384	32% Overall on this WBS
Total cost		\$195,460	

NCSX Fabrication Project Cost and Schedule

WBS 123 Vacuum Vessel Heating and Cooling system

Engineering, Title I, II and III

Description:

This effort covers all Title I, II, and III engineering for the vacuum vessel heating and cooling distribution system, which includes the cooling lines wrapped on the vessel shell and port extensions and the necessary manifolding and connections to interface with the ex-cryostat helium supply system. The heating and cooling 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
Title I, II design															
Pro-E models (avg)	4	hrs/model	26	104	1.00	0.00	0	0.00	0	1.00	104	0.00	0	0.00	0
assy dwgs	8	hrs/dwg	4	32	1.00	0.00	0	0.00	0	1.00	32	0.00	0	0.00	0
Detail drawings	4	hrs/dwg	1	4	1.00	0.00	0	0.00	0	1.00	4	0.00	0	0.00	0
installation dwg	8	hrs/dwg	4	32	1.00	0.00	0	0.00	0	1.00	32	0.00	0	0.00	0
cooling schematic	20	hrs/dwg	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	0.00	0
electrical schematic	0	hrs/dwg	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	0.00	0
I&C schematic	20	hrs/dwg	0	0	1.00	0.00	0	0.00	0	1.00	0	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	40	hrs/spec	1	40	1.00	0.75	30	0.00	0	0.25	10	0.00	0	0.00	0
preliminary and final design reviews	40	hrs/rev	1	40	1.00	0.00	0	0.00	0	1.00	40	0.00	0	0.00	0
meetings/reporting/presentations	10%	% of tot	292	29	1.00	0.00	0	0.00	0	1.00	29	0.00	0	0.00	0
<i>subtotal</i>				321			30		0		291		0		0
Title III															
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	9	18	1.00	0.00	0	0.00	0	0.00	0	1.00	18		
<i>subtotal</i>				56			8		0		0		48		

NCSX Fabrication Project Cost and Schedule

WBS 123 Vacuum Vessel Heating and Cooling system

Engineering, Title I, II and III

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	12	Sep-06
Installation / final assembly	Sep-06	14	Jan-07

Notes and worksheets

vessel thermal insulation blankets

	total	vessel torus,	port extensions	NBI duct	connecting pipes	headers
Pro-E models	26	10	13	2	1	2 models for each type of tube, manifold, and header
assy dwgs	4	1	1	1	1	1
Detail drawings	1	0	0	0	1	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%					

WBS 123 Vacuum Vessel Heating and Cooling system

R&D

Description:
No R&D is expected for this WBS element

Summary

Purchased Design Services	\$0
<i>subtotal</i>	\$0 w/o GSA
Procured Hardware/Material	\$0
<i>subtotal</i>	\$0 w/o GSA

Subcontractor labor rates:
 design rate: \$n per hour
 fab rate: \$0 per hour
 inspection/technician rate: \$0 per hour

R&D design	unit	no.	hours	Labor category										
				total fraction	EAEM fract.	EAEM hrs	EADM fract.	EADM hrs	ORNL Eqg fract.	ORNL Eqg hrs	EASM fract.	EASM hrs	Vendor fract.	Vendor hrs
Task														
Pro-E models	24 hrs/model	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	0.00	0
assy dwgs	20 hrs/dwg	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	0.00	0
Detail drawings	24 hrs/dwg	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	0.00	0
installation dwg	0 hrs/dwg	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	0.00	0
cooling schematic	0 hrs/dwg	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	0.00	0
electrical schematic	0 hrs/dwg	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	0.00	0
I&C schematic	0 hrs/dwg	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	0.00	0
special analysis	0 hrs/calc	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	0.00	0
procurement specifications	80 hrs/spec	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	0.00	0
vendor shop drawings	0 hrs/dwg	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	1.00	0
vendor part programming	0 hrs/model	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	1.00	0
vendor misc engineering	0 % of tot	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	1.00	0
preliminary and final design reviews	80 hrs/rev	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	0.00	0
meetings/visitor/representations	20% % of tot	0	0	1.00	0.00	0	0.00	0	1.00	0	0.00	0	0.00	0
<i>subtotal</i>			0			0			0				0	
				total fraction	EAEM fract.	EAEM hrs	EADM fract.	EADM hrs	ORNL Eqg fract.	ORNL Eqg hrs	EASM fract.	EASM hrs	EMTB fract.	EMTB hrs
R&D Tasks and Title III (see notes)														
Procurement assistance	0 hrs/wk	12	0	1.00	0.50	0	0.00	0	0.50	0	0.00	0	0.00	0
Vendor surveillance, oversight	0 hrs/wk	52	0	1.00	0.50	0	0.00	0	0.50	0	0.00	0	0.00	0
Disposition of deviation requests and non-conformances	0 hrs/wk	52	0	1.00	0.25	0	0.00	0	0.75	0	0.00	0	0.00	0
<i>subtotal</i>			0			0			0				0	
Schedule assumptions	start	duration (weeks)	end											
Bid and award	Jul-03	12	Oct-03											
Vessel R&D	Oct-03	52	Sep-04											

Notes and worksheets



WBS 123 Vacuum Vessel Heating and Cooling system

Materials and Subcontracts (M&S)

Description:
This effort covers procurement of materials for the vacuum vessel heating and cooling system lines, manifolding and headers by fixed price subcontract.

Assumptions:
outside engr rate = 120 \$ per hour
outside lab rate = 60 \$ per hour
outside inspection/technician rate = 90 \$ per hour

Purchased parts:
coolant line tracing on VV shell \$14,400 see notes below
coolant line tracing on port extensions \$5,844
coolant line tracing on NBI ducts \$5,844
manifold piping, connections \$19,980
header piping, connections \$4,546
heat transfer goop \$17,198
subtotal, purchased parts \$67,799

Worksheet:

coolant line tracing on VV shell
avg potoidal perimeter of torus 20 ft
spacing of tubes 0.5 ft
approx no. potoidal loops/period 32
cost of tubing \$3 per foot, Inco 600
cost per field period \$1,060
spacing of tube hold-downs 0.25 ft
no. of hold-downs/period 2500 connections
cost per hold-down \$1 simple spot-welded strip
cost per field period \$2,560
hydraulic conn's per pot. loop 2
no. of hydraulic conn's/period 64
matl. cost per connection \$5 swaabelock connection
cost per field period \$320

total matl cost for torus tracing \$14,400

coolant line tracing on port extensions
avg length of port 3 ft
avg perimeter of port ext. 3 ft
spacing of tubes 0.5 ft
approx no. Loops / port ext 6
length of tube per port extension 16 ft
no. of port ext. 22 per period
cost of tubing \$3 per foot, Inco 600
cost per field period \$1,037
spacing of tube hold-downs 0.5 ft
no. of hold-downs/period 691 connections
cost per hold-down \$1 simple spot-welded strip
cost per field period \$691
hydraulic conn's per port ext 2
no. of hyd conn's/period 44
matl. cost per connection \$5 swaabelock connection
cost per field period \$220

total matl cost for port ext.tracing \$6,844

coolant line tracing on NBI ducts
length of port 3 ft
avg perimeter of port 12 ft
spacing of tubes 0.5 ft
approx no. Loops / port ext 6
length of tube per port extension 72 ft
no. of NBI port ext. 1 per period
cost of tubing \$3 per foot, Inco 600
cost per field period \$216
spacing of tube hold-downs 0.5 ft
no. of hold-downs/period 144 connections
cost per hold-down \$1 simple spot-welded strip
cost per field period \$144
hydraulic conn's per port ext 2
no. of hyd conn's/period 4
matl. cost per connection \$5 swaabelock connection
cost per field period \$20

total matl cost for NBI port tracing \$1,140

Connecting tubes
Assume 7 loops per field period connecting all ports and torus piping in series within that 1/7 of a period
assume same type tubing for connecting from component to component
A pair of lines will also connect the loop to the headers below the machine.

avg potoidal perimeter of torus 14 ft
total number of coolant connection tubes per period 90
cost of tubing \$3 per foot, Inco 600
cost per field period \$3,780
cost per welded nipple \$2 simple spot-welded strip
cost of nipples for all manifolds \$16,200
welding consumables \$500 total

total matl cost for manifolds \$19,980

Headers for cooling lines

Assume 1 pair of 1 inch ring headers for the VV heating piping that ride with and are installed with each of the field periods

avg toroidal perimeter of field period 17 ft
no of header pairs 3
cost of tubing \$15 per foot, Inco 600
total number of coolant connections, all headers \$1,546
cost per connection \$5
cost of nipples for all manifolds \$2,700
welding consumables \$200 total
no. connections for supply piping 6 2 connections per manifold pair
cost per connection \$50
cost for supply piping connections \$300
total matl cost for manifolds \$4,546

Heat transfer goop

WBS 123 Vacuum Vessel Heating and Cooling system

In-house Fabrication and Assembly

Description:

This effort describes the assembly time to put the cooling line tracing on the exterior of the vessel and ports, and includes the time to build the coolant headers. The actual cooling line assembly time is covered in WBS 184.

Labor category

multiloiter	unit	no.	hours	total		EASM,		EMTD		EADM			
				fraction	hrs	frac.	hrs	frac.	hrs	frac.	hrs		
Fab operations summary													
Connecting tubes	59	hrs/lot	1	59	1.00	0.00	0	0.20	12	0.80	47	0.00	0
Headers for cooling manifolds	113	hrs/line	1	113	1.00	0.00	0	0.20	23	0.80	90	0.00	0
	0	hrs / coil	1	0	0.00	0.00	0	0.00	0	0.00	0	0.00	0
subtotal				171			0	34.3			137	0	

multiloiter	unit	no.	hours	total		EASM,		EMTD		EADM			
				fraction	hrs	frac.	hrs	frac.	hrs	frac.	hrs		
Assembly operations summary*													
coolant line tracing on VV shell	0	hr/period	3	0	1.00	0.00	0	0.20	0	0.80	0	0.00	0
coolant line tracing on port extension	0	hr/period	3	0	1.00	0.00	0	0.20	0	0.80	0	0.00	0
coolant line tracing on NBI ducts	0	hr/period	1	0	1.00	0.00	0	0.20	0	0.80	0	0.00	0
apply heat transfer goop	0	hours/period	3	0	1.00	0.00	0	0	1.00	0	0.00	0	0
subtotal				0			0	0			0	0	

* included in WBS 184

Worksheets

coolant line tracing on VV shell

ava axial/perimeter of torus	20	ft
spacing of tubes	0.5	ft
approx no. axial/loops/period	32	
spacing of tube hold-downs	0.25	ft
no. of hold down/period	2560	hold-downs
hydraulic losses per period	32	
no. of hydraulic connections	64	
hours per connection	0.5	hours
forming tube, feet per shift	40	
crew size for forming, hold-downs	2	
shifts per field period	20	shifts
tech hours per field period	320	hours/period
technical oversight, inspection	80	hrs/period
total hours, tracing on torus	400	

coolant line tracing on port extensions

ava length of port	3	ft
ava perimeter of port ext.	3	ft
spacing of tubes	0.5	ft
approx no. Loops / port ext	6	
length of tube per port extension	16	ft
no. of port ext.	22	per period
spacing of tube hold-downs	0.5	ft
no. of hold down/period	691	hold-downs
hydraulic conns per port ext	2	
no. of hvd connections	44	
hours per connection	0.5	hours
forming tube, feet per shift	40	
crew size for forming, connecting	2	
shifts per field period	11	shifts
tech hours per field period	182	hours/period
technical oversight, inspection	46	hrs/period
total hours, tracing on ports	228	

coolant line tracing on NBI ducts

length of port	3	ft
ava perimeter of port	12	ft
spacing of tubes	0.5	ft
approx no. Loops / port ext	6	
length of tube per port extension	72	ft
no. of NBI port ext.	1	per period
spacing of tube hold-downs	0.5	ft
no. of hold down/period	144	connections
hydraulic paths per port ext	2	
no. of hvd connections	4	
hours per connection	0.5	hours
forming tube, feet per shift	40	
crew size for forming, connecting	2	
shifts per field period	2.3	shifts
tech hours per field period	98	hours, all nbi ducts
technical oversight, inspection	25	hours, all nbi ducts

Connecting tubes

Assume 7 loops per field period connecting all ports and torus piping in series within that 1/7 of a period
assume same type tubing for connecting from component to component
A pair of lines will also connect the loop to the headers below the machine.

ava axial/perimeter of torus	14	ft
total length of tubing	7	ft
total number of coolant connection tubes per period	90	
hours to cut tubes and make swagel	0.5	per connecting tubes
shifts to form connecting tubes	0.125	per manifold pair
crew size for forming	2	
total shifts for connecting tube	6	
tech hours for connecting tubes	47	hours
technical oversight, inspection	12	hrs

Headers for cooling manifolds

Assume 1 pair of 1 inch ring headers for the VV heating piping that ride with and are installed with each of the field periods

ava toroidal perimeter of field period	17	ft
no of header coils	3	
total number of coolant connections, all headers	42	
hours to weld each connection	1	hr per connection
shifts to form header tube	1	per manifold pair
crew size for forming	2	
no. connections for suonly coils	6	for 2 connections per manifold pair
hours to weld each connection	4	hrs
total hours to weld suonly coils con.	24	hrs
total shifts for headers	11	shifts
total tech hours for headers	95	
technical oversight, inspection	22.5	