# NCSX Fabrication Project Cost and Schedule Estimating Form

## WBS 124 Vacuum Vessel Supports

### Labor

| Activity Title | Manhours | FY2003 $$ | Labor Type | Start Date Month/Yr | End Date Month/Yr | Comments |
|---|---|---|---|---|---|---|
| **Preliminary Design (Title I)** | | | | | | |
| ( 50% of design schedule) | 0 | | *EAEM* | Apr-03 | Nov-03 | PPPL Engineer |
| | 0 | | *EADM* | Apr-03 | Nov-03 | PPPL Designer |
| | 158 | | *ORNL Eng* | Apr-03 | Nov-03 | Composite of ORNL Engineer / Designer |
| | 0 | | *ORNL Phys.* | Apr-03 | Nov-03 | Composite of ORNL Physics / scientific |
| | 0 | | *PPPL Phys.* | Apr-03 | Nov-03 | PPPL Physics/scientific |
| **Final Design (Title II)** | | | | | | |
| ( 50% of design schedule) | 0 | | *EAEM* | Dec-05 | Jan-06 | PPPL Engineer |
| | 0 | | *EADM* | Dec-05 | Jan-06 | PPPL Designer |
| | 158 | | *ORNL Eng* | Dec-05 | Jan-06 | Composite of ORNL Engineer / Designer |
| | 0 | | *ORNL Phys.* | Dec-05 | Jan-06 | Composite of ORNL Physicist |
| | 0 | | *PPPL Phys.* | Dec-05 | Jan-06 | PPPL Physics/scientific |
| **Lab R&D labor** | | | | | | |
| | 0 | | *EAEM* | Apr-03 | Nov-03 | PPPL Engineer |
| | 0 | | *EADM* | Apr-03 | Nov-03 | PPPL Designer |
| | 0 | | *ORNL Eng* | Apr-03 | Nov-03 | Composite of ORNL Engineer / Designer |
| | 0 | | *EASM* | Apr-03 | Nov-03 | PPPL monthly support |
| | 0 | | *EMTB* | Apr-03 | Nov-03 | PPPL Technician |
| **Lab Fab/Assembly/Installation (Title III)** | | | | | | |
| | 2 | | *EAEM* | Jan-06 | Jun-06 | PPPL Engineer |
| | 0 | | *EADM* | Jan-06 | Jun-06 | PPPL Designer |
| | 60 | | *ORNL Eng* | Jan-06 | Jun-06 | Composite of ORNL Engineer / Designer |
| | 6 | | *EASM* | Jan-06 | Jun-06 | PPPL monthly support |
| | 0 | | *EMTB* | Jan-06 | Jun-06 | PPPL Technician |

# WBS 124 Vacuum Vessel Supports

## Labor

*Manhours per fiscal year by labor category*

| Level of Effort | | FY2003 | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | TOTAL |
|---|---|---|---|---|---|---|---|---|
| PPPL Engineer | *EAEM* | 0 | 0 | 0 | 2 | 0 | 0 | *2* |
| PPPL Designer | *EADM* | 0 | 0 | 0 | 0 | 0 | 0 | *0* |
| Composite of ORNL Engineer / Designer | *ORNL Eng* | 131 | 28 | 0 | 218 | 0 | 0 | *377* |
| PPPL monthly support | *EASM* | 0 | 0 | 0 | 6 | 0 | 0 | *6* |
| PPPL Technician | *EMTB* | 0 | 0 | 0 | 0 | 0 | 0 | *0* |
| Composite of ORNL Physics / scientific | *ORNL Phy* | 0 | 0 | 0 | 0 | 0 | 0 | *0* |
| PPPL Physics/scientific | *PPPL Phy* | 0 | 0 | 0 | 0 | 0 | 0 | *0* |

# WBS 124 Vacuum Vessel Supports

## M&S Costs

| Activity Title | FY2003 $$ | Comment |
|---|---|---|
| **Manufacturing Development (R&D)** | | |
| Purchased Design Services | $0 | |
| Procured Hardware/Material | $0 | |
| Profit at 10% | $0 | |
| *total, manf/dev (R&D)* | $0 | w/o G&A |
| | | |
| **Procured Hardware/Material** | | |
| set of 12 vert.rods and hardware | $7,757 | |
| 12 extension tubes for shell | $7,521 | |
| | $0 | |
| materials for in-house fab | $0 | |
| subtotal, purchased parts | $23,319 | |
| Profit at 10% | $776 | |
| *total, procured hdwe/matl.* | $24,094 | 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 travel is anticipated for this WBS** |

## Summary Costs

| Activity Title | Manhours | FY2003 $$ | Comment |
|---|---|---|---|

## NCSX Fabrication Project Cost and Schedule Estimating Form

# WBS 124 Vacuum Vessel Supports

| | | | | | | |
|---|---|---|---|---|---|---|
| **Labor** | | | | | | |
| PPPL Effort | 8 | $906 | *Assumed rates:* | | *EASM* | 100 $/hr |
| ORNL effort | 377 | $48,984 | *EAEM* | 153 $/hr | *EMTB* | 73 $/hr |
| subtotal, labor | 385 | $49,890 | *EADM* | 100 $/hr | PPPL Phys | 141 $/hr |
| | | | *ORNL Eng* | 130 $/hr | ORNL Phys | 160 $/hr |
| **M&S, Other** | | | | | | |
| Manufacturing Development (R&D) | | $0 | | | | |
| Procured Hardware/Material | | $24,094 | | | | |
| Purchased Design Services | | $0 | | | | |
| Procured Installation/Assembly Costs | | $0 | | | | |
| Travel | | $0 | | | | |
| subtotal, M&S | | $24,094 | | | | |
| **G&A** | | $6,024 | 25% | on all purchased materials, subcontracts, travel | | |
| **Subtotal without contingency** | | $80,008 | | | | |
| **Contingency** | | $24,002 | 30% | Overall on this WBS | | |
| **Total cost** | | $104,010 | | | | |

# NCSX Fabrication Project Cost and Schedule

## WBS 124 Vacuum Vessel Supports

### Engineering, Title I, II and III

**Description:**
This effort covers all Title I, II, and III engineering for the Vacuum Vessel Supports. The supports will be procured from a qualified vendor. All installation oversight will be performed as part of WBS 7.

| | | | | | | Labor category | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | fraction | EAEM | | EADM | | ORNL Eng | | ORNL Physics | | PPPL Physics | |
| | multiplier | unit | no. | hours | | fract. | hrs | fract. | hrs | fract. | hrs | fract. | hrs | fract. | hrs |
| **Title I, II design** | | | | | | | | | | | | | | | |
| Pro-E models | 4 | hrs/model | 8 | 32 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 32 | 0.00 | 0 | 0.00 | 0 |
| assy dwgs | 16 | hrs/dwg | 2 | 32 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 32 | 0.00 | 0 | 0.00 | 0 |
| Detail drawings | 12 | hrs/dwg | 8 | 96 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 96 | 0.00 | 0 | 0.00 | 0 |
| installation dwg | 16 | hrs/dwg | 5 | 80 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 80 | 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 | 8 | hrs/dwg | 0 | 0 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| I&C schematic | 8 | hrs/dwg | 0 | 0 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| stress analysis | 24 | hrs/calc | 1 | 24 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 24 | 0.00 | 0 | 0.00 | 0 |
| thermal analysis | 24 | hrs/calc | 1 | 24 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 24 | 0.00 | 0 | 0.00 | 0 |
| special analysis | 40 | hrs/calc | 0 | 0 | 1.00 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 |
| procurement specifications | 16 | hrs/spec | 0 | 0 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| preliminary and final design reviews | 0 | hrs/rev | 0 | 0 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| meetings/reporting/presentations | 10% | % of tot | 288 | 29 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 29 | 0.00 | 0 | 0.00 | 0 |
| *subtotal* | | | | *317* | | | *0* | | *0* | | *317* | | *0* | | *0* |

| | | | | | total fraction | EAEM | | EASM | | EADM | | ORNL Eng | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Title III** | | | | | | fract. | hrs | fract. | hrs | fract. | hrs | fract. | hrs |
| vendor oversight, inspection | 8 | hrs/lot | 1 | 8 | 0.00 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| in-house fab/assy oversight and inspection | 0 | hrs/wk | 4 | 0 | 1.00 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| Disposition of deviation requests and non-conformances | 1 | hrs/wk | 20 | 20 | 0.00 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| As-built drawings | 4 | hrs/dwg | 15 | 60 | 1.00 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 1.00 | 60 |
| Installation oversight and inspection | 2 | hrs/wk | 4 | 8 | 1.00 | 0.25 | 2 | 0.75 | 6 | 0.00 | 0 | 0.00 | 0 |
| *subtotal* | | | | *96* | | | *2* | | *6* | | *0* | | *60* |

# WBS 124 Vacuum Vessel Supports

## Engineering, Title I, II and III

| Schedule assumptions | start | duration (weeks) | end |
|---|---|---|---|
| Title I Design, R&D | Apr-03 | 6 | Nov-03 |
| Title II Design | Dec-05 | 6 | Jan-06 |
| Procurement | Jan-06 | 12 | Apr-06 |
| In-house fab / sub-assy | Apr-06 | 4 | May-06 |
| Installation / final assembly | May-06 | 4 | Jun-06 |

**Notes and worksheets**

**vacuum vessel supports**

| | total | support rods and hardware | shell extension tubes | |
|---|---|---|---|---|
| Pro-E models | 8 | 4 | 4 | |
| assy dwgs | 2 | 1 | 1 | |
| Detail drawings | 8 | 4 | 4 | |
| installation dwg | 5 | 1 | 4 | one installation drawing for each location |
| cooling schematic | 0 | | | |
| electrical schematic | 0 | | | |
| I&C schematic | 0 | | | |
| stress analysis | 1 | 1 | | one stress analysis |
| thermal analysis | 1 | 1 | | one thermal analysis |
| special analysis | 0 | | | |
| procurement specifications | 0 | | | one specification for rods, one for tubes |
| preliminary and final design reviews | 0 | | | review for vessel supports included in WBS 121 |
| meetings/reporting/presentations | 15% | | | |

# WBS 124 Vacuum Vessel Supports

## R&D

**Description:**
No R&D is anticipated for this WBS element, but vendor will have non-recurring engineering costs to ensure low temperature capability

**Summary**

| | | |
|---|---|---|
| Purchased Design Services | $0 | w/o G&A |
| design rate | $120 | per hour |
| Procured Hardware/Material | $0 | w/o G&A |
| fab rate | $60 | per hour |
| inspection/technician rate | $80 | per hour |

| **R&D design** | | **unit** | **no.** | **hours** | total fraction | EAEM fract. | EAEM hrs | EADM fract. | EADM hrs | ORNL Eng fract. | ORNL Eng hrs | EASM fract. | EASM hrs | Vendor fract. | Vendor hrs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **Labor category** | | | | | | | | | |
| **Task** | | | | | | | | | | | | | | | |
| Pro-E models | 0 | hrs/model | 0 | 0 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| assy dwgs | 0 | hrs/dwg | 0 | 0 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| Detail drawings | 0 | 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 | 8 | 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 | | | | | | | | | 1.00 | 0 |
| vendor part programming | 0 | hrs/model | 0 | 0 | 1.00 | | | | | | | | | 1.00 | 0 |
| vendor misc engineering | 20% | % of tot | 0 | 0 | 1.00 | | | | | | | | | 1.00 | 0 |
| preliminary and final design reviews | 0 | hrs/rev | 0 | 0 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| meetings/reporting/presentations | 10% | % of tot | 0 | 0 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| *subtotal* | | | | *0* | | | *0* | | *0* | | *0* | | *0* | | *0* |

| **R&D Title III** | | | | | total fraction | EAEM fract. | EAEM hrs | EADM fract. | EADM hrs | ORNL Eng fract. | ORNL Eng hrs | EASM fract. | EASM hrs | EMTB fract. | EMTB hrs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| vendor oversight, inspection | 0 | hrs/wk | 4 | 0 | 1.00 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 |
| in-house fab/assy, oversight, and inspection | 0 | hrs/wk | 4 | 0 | 1.00 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 |
| Testing and experiments | 0 | hrs/wk | 1 | 0 | 1.00 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 |
| *subtotal* | | | | *0* | | | *0* | | *0* | | *0* | | *0* | | *0* |

| **Schedule assumptions** | **start** | **duration (weeks)** | **end** |
|---|---|---|---|
| R&D planning | Sep-03 | 4 | Oct-03 |
| Bid and award | Oct-03 | 2 | Oct-03 |
| R&D procurement / in-house fab. | Oct-03 | 4 | Nov-03 |
| R&D testing | Nov-03 | 1 | Nov-03 |

**Notes and worksheets**

# WBS 124 Vacuum Vessel Supports

## Materials and Subcontracts (M&S)

**Description:**
This effort covers the vacuum vessel supports that connect the vessel to the modular coil shell structure. The supports will be procured from a qualified vendor. All installation will be performed as part of WBS 7.

**Assumptions:**

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

**Purchased parts:**

| | |
|---|---|
| set of 12 vert.rods and hardware | $7,757 |
| 12 extension tubes for shell | $7,521 |
| Lateral supports | $5,280 |
| Shell lateral brackets | $2,760 |
| *subtotal, purchased parts* | $23,319 |

Leads consist of "kickless" cable with factory split terminations and gas bleed cooling
Leads connect from coil terminals to buswork at bottom of machine.
Leads will be routed to 3 locations corresponding to 3 buswork feeds for each field period

**Purchased materials for in-house fabrication and sub-assembly**

| | |
|---|---|
| None required | $0 |
| *subtotal purchased materials* | 0 |

**Worksheet:**

**Vertical Rods**

| | | | | |
|---|---|---|---|---|
| no.of rods | 16 | ea | dia (in) | length (in) |
| rod weight | 8 | lbs | 1 | 36 |
| rod material cost @ 10$/lb | $85 | per rod | | |
| rod machining | 200 | per rod | | |
| spherical bushings, nuts, etc. | $200 | per rod | | |
| Total rod and hardware cost | $7,757 | | | |

**Shell extension tubes**

| Tube geometry | inboard 1 | inboard 2 | inboard 3 | inboard 4 |
|---|---|---|---|---|
| No. of tubes | 6 | 6 | 6 | 6 |
| dia of tubes (in) | 4 | 4 | 4 | 4 |
| thickness (in) | 0.5 | 0.5 | 0.5 | 0.5 |
| Lengths (in) | 10.00 | 5.00 | 24.0 | 16.0 |
| weight (lbs) | 16 | 8 | 40 | 26 |
| matl @ $5/lb | $82 | $41 | $198 | $132 |
| machining, each | $200 | $200 | $200 | $200 |
| Subtotals, ea | $282 | $241 | $398 | $332 |
| totals by type | $1,695 | $1,447 | $2,388 | $1,992 |
| Total cost | $7,521 | | | |

**Lateral supports**

| | | | | | |
|---|---|---|---|---|---|
| no.of gibs | 12 | ea | width | length (in) | thickness |
| gib weight | 9 | lbs | 3 | 5 | 2 |
| gib material cost @ 10$/lb | $90 | per gib | | | |
| gib machining | $250 | per gib | | | |
| special bolts | $100 | per gib | | | |

# WBS 124 Vacuum Vessel Supports

## In-house Fabrication and Assembly

**Description:**
No local fab or assembly is anticipated for the vessel support rods. Installation is part of WBS 7.

**Labor category**

| | multiplier | unit | no. | hours | total fraction | EAEM fract. | EAEM hrs | EASM fract. | EASM hrs | EMTB fract. | EMTB hrs | ORNL Eng fract. | ORNL Eng hrs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Fab operations** | | | | | | | | | | | | | |
| | | | | 0 | 0.00 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| none anticipated | 0 | hrs/tile | 0 | 0 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 |
| | | | | 0 | 0.00 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| | | | | 0 | 0.00 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| | | | | 0 | 0.00 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| *subtotal* | | | | *0* | | | *0* | | *0* | | *0* | | *0* |

| | | | | | total fraction | EAEM fract. | EAEM hrs | EASM fract. | EASM hrs | EMTB fract. | EMTB hrs | ORNL Eng fract. | ORNL Eng hrs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Assembly operations** | | | | | | | | | | | | | |
| none anticipated | | man/shift | | 0 | 1.00 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| | | man/shift | | 0 | 1.00 | 0.00 | 0 | 0.00 | 0 | 1.00 | 0 | 0.00 | 0 |
| | | man/shift | | 0 | 0.00 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| | | man/shift | | 0 | 0.00 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| | | | | | 0.00 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| *subtotal* | | | | *0* | | | *0* | | *0* | | *0* | | *0* |

| **Schedule assumptions** | **start** | **duration (weeks)** | **end** |
|---|---|---|---|
| Title I Design, R&D | Apr-03 | 6 | Nov-03 |
| Title II Design | Dec-05 | 6 | Jan-06 |
| Procurement | Jan-06 | 12 | Apr-06 |
| In-house fab / sub-assy | Apr-06 | 4 | May-06 |
| Installation / final assembly | May-06 | 4 | Jun-06 |

**Notes and worksheets**