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# Update of ARIES-AT Vacuum Vessel Design

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The Boeing Company

19 June 2000

ARIES Meeting at UW, Madison

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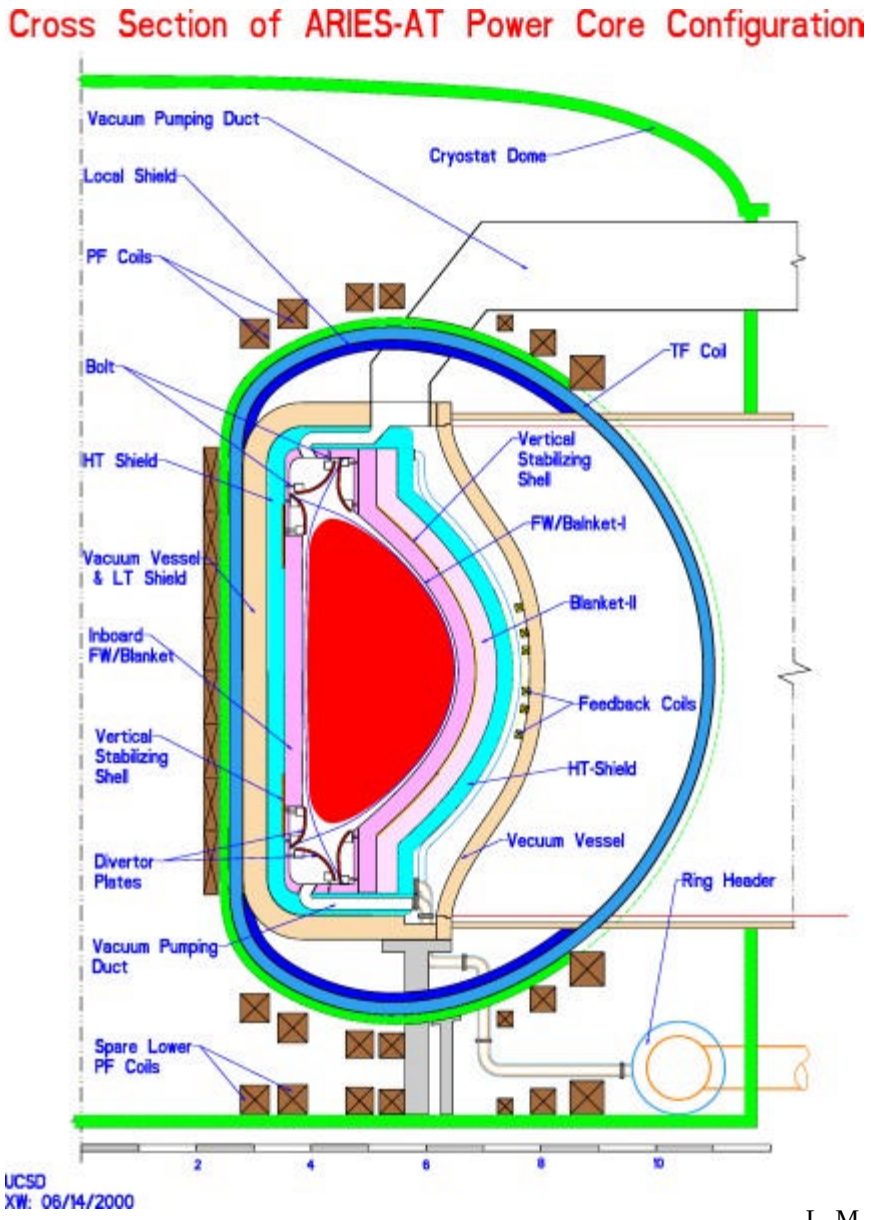
# ARIES-AT Power Core

- Sector replacement approach
- Individual doors and port enclosures for each power core sector
- Discrete vacuum vessel doors
- Vacuum vessel provides support for power core



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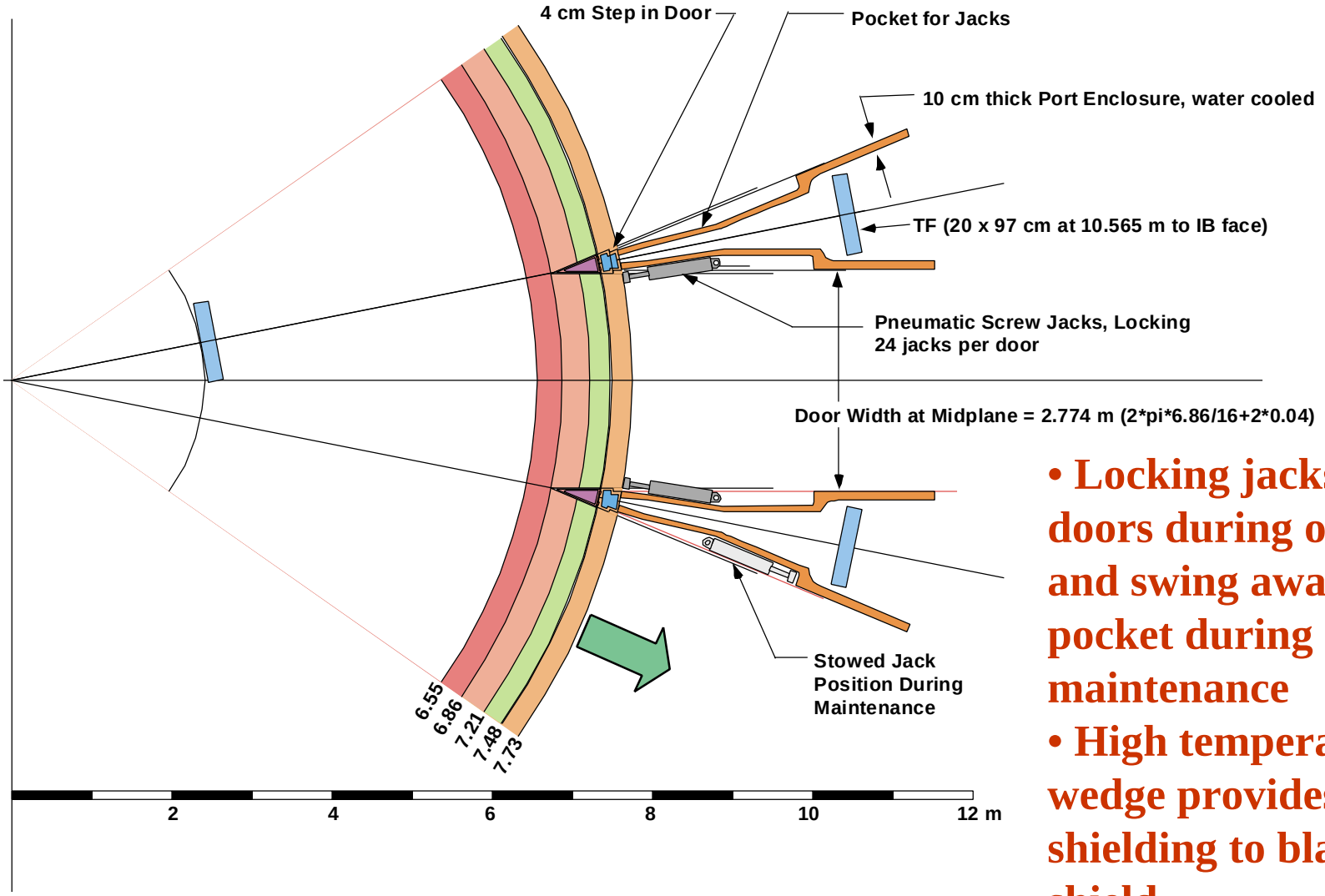
# Vacuum Vessel Port Design Approach




- Locking jacks secure doors during operation and swing away into pocket during maintenance
- High temperature wedge provides similar shielding to blanket and shield



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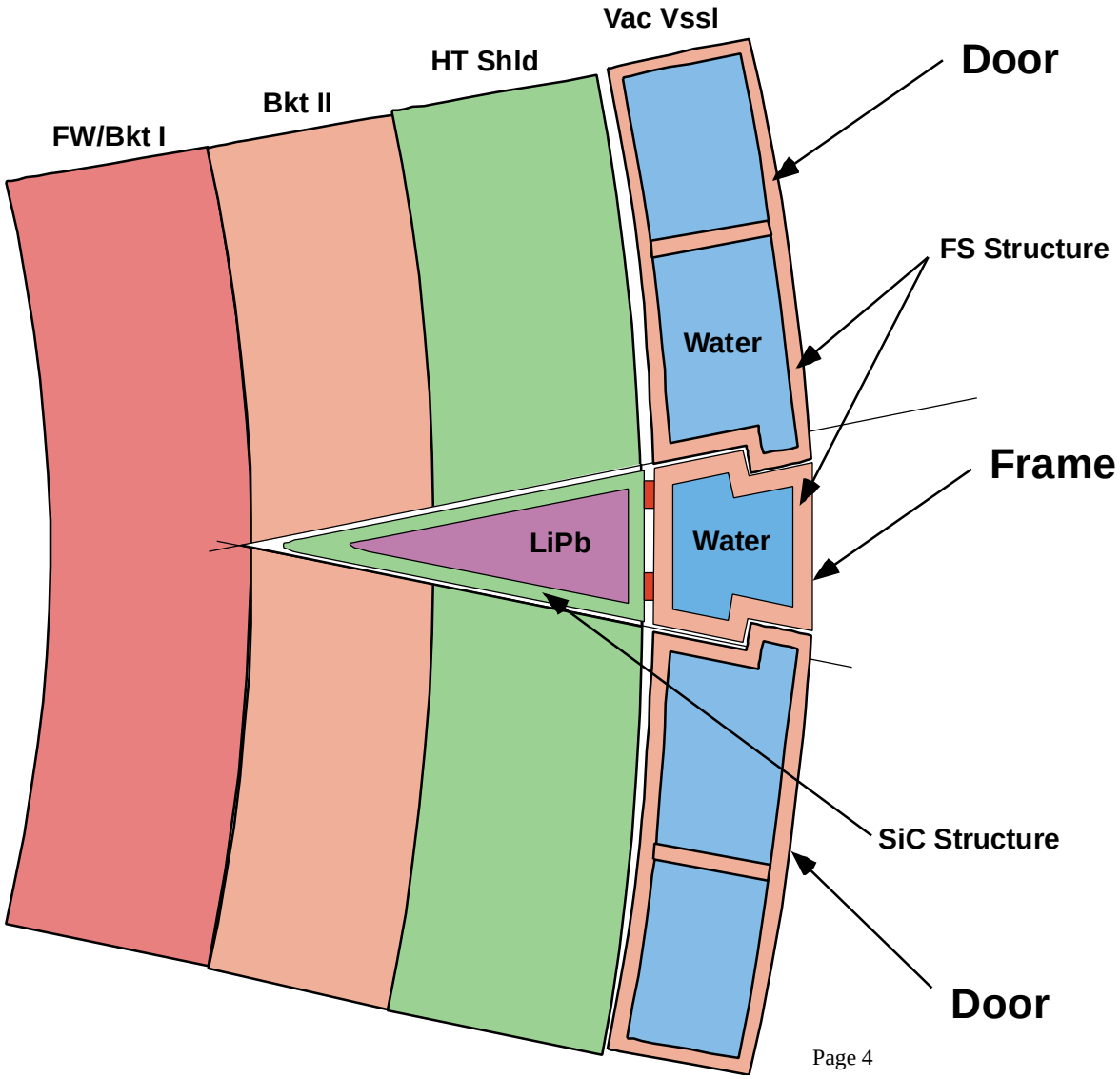
# HT Wedge Detail




- Door and frame steps attenuate neutron streaming and provide positive door positioning.
- LiPb coolant is routed in and out through upper and lower vacuum vessel spool flanges



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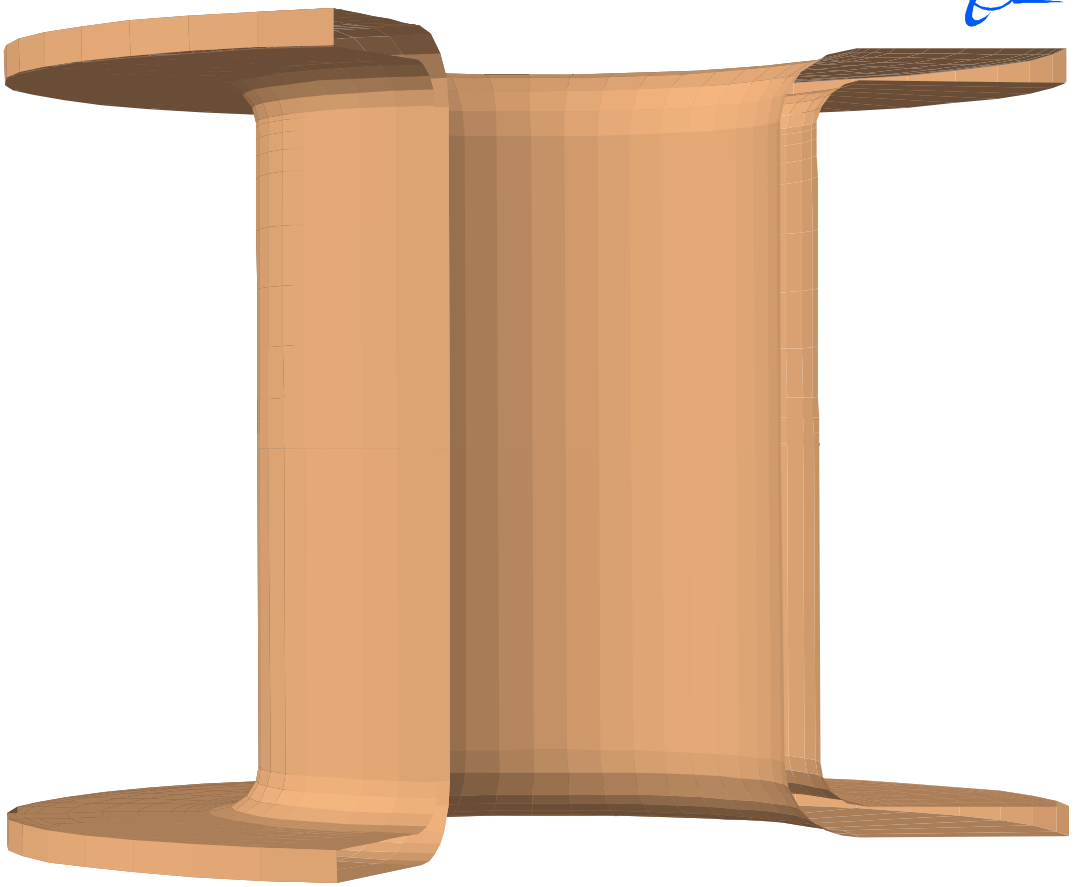
# 3-D View of Basic Vacuum Vessel



3-D Cutway View of Vacuum Vessel

**Notes:**

- Vessel is a double-walled structure with internal ribs (not shown).
- Water coolant is circulated between external walls.
- Cutouts for plumbing connections are not shown.
- Structure will be welded as required to form complete assembly.
- Door frames will be welded to spool-shaped basic structure.



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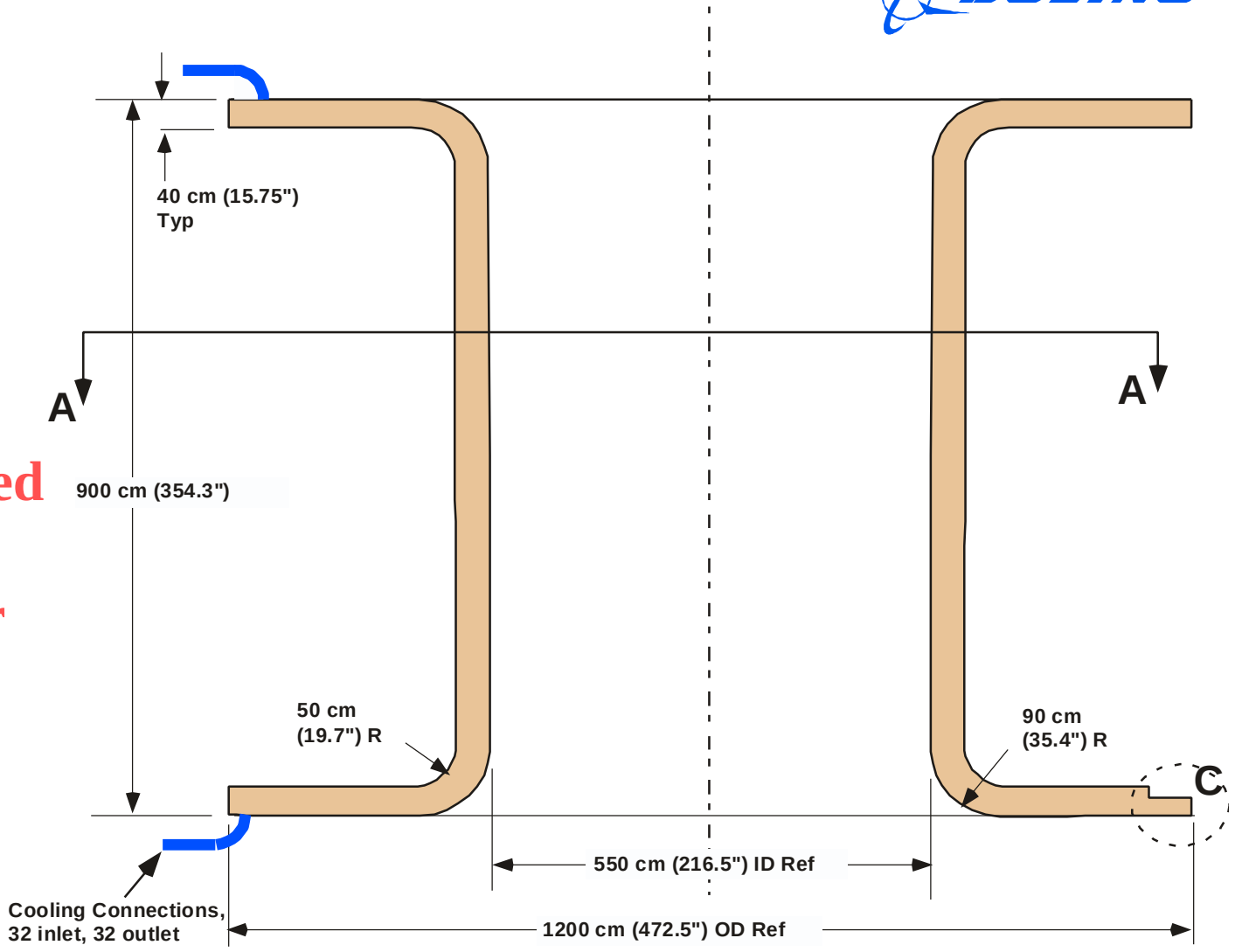
# Basic Structure, Elevation View

- Double-walled vessel allows internal water cooling
- Structure is constructed mainly of flat plates




**Elevation View**

**Material: Low Activation Ferritic Steel, F82H (Fe-8%Cr-2%WVTa)**



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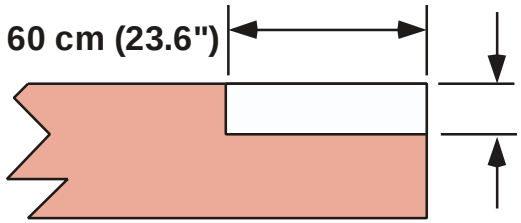
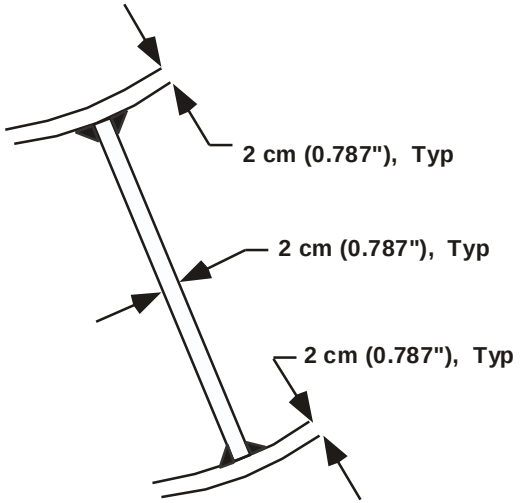
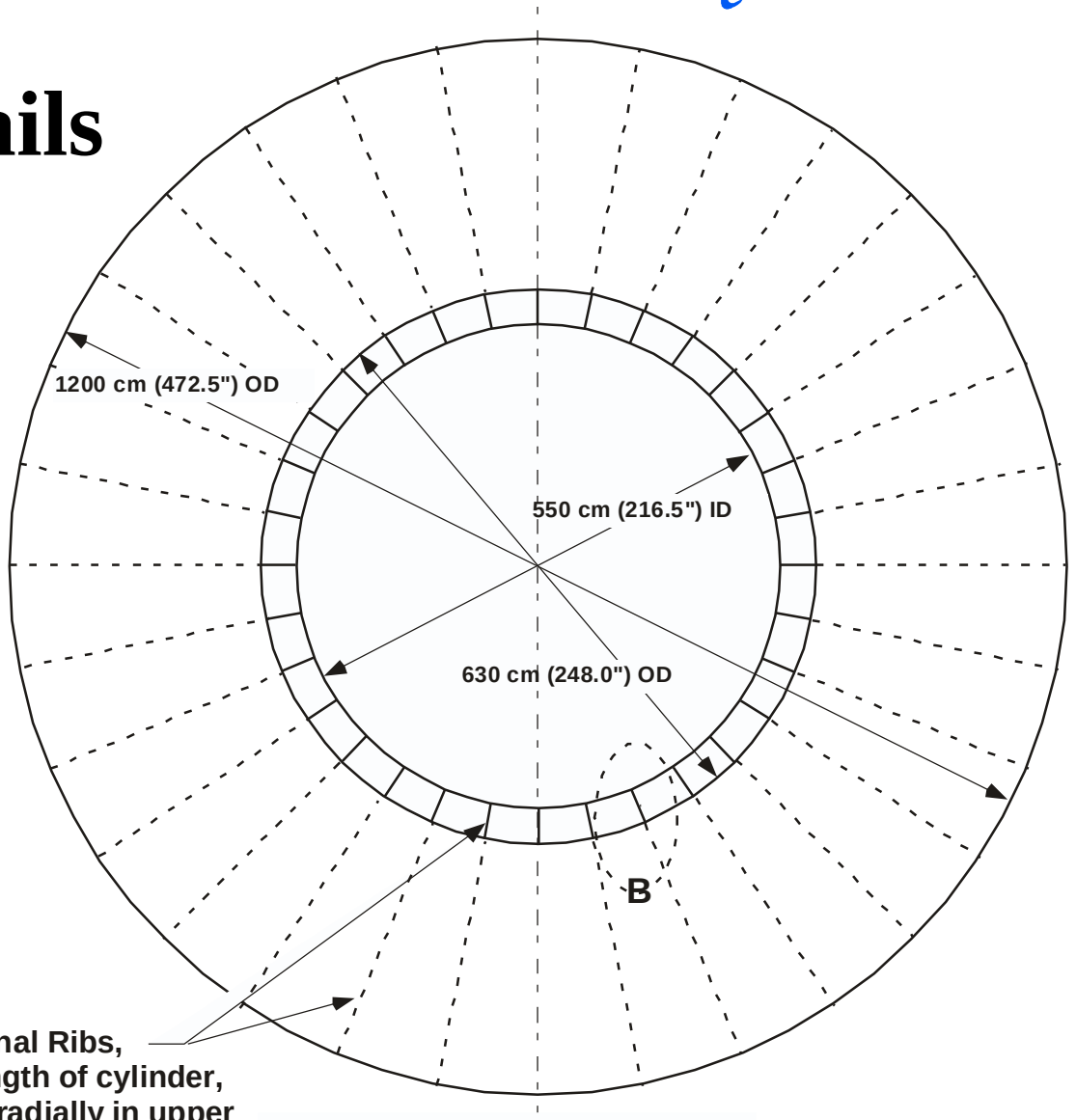
# Structure Details




View C - Plumbing Cutout
Typical 16 places, 50 cm deep




View B - Rib Detail
(10 x view)




32 Internal Ribs,
Full Length of cylinder,
Extend radially in upper
and lower flanges

A-A Midplane Crossection



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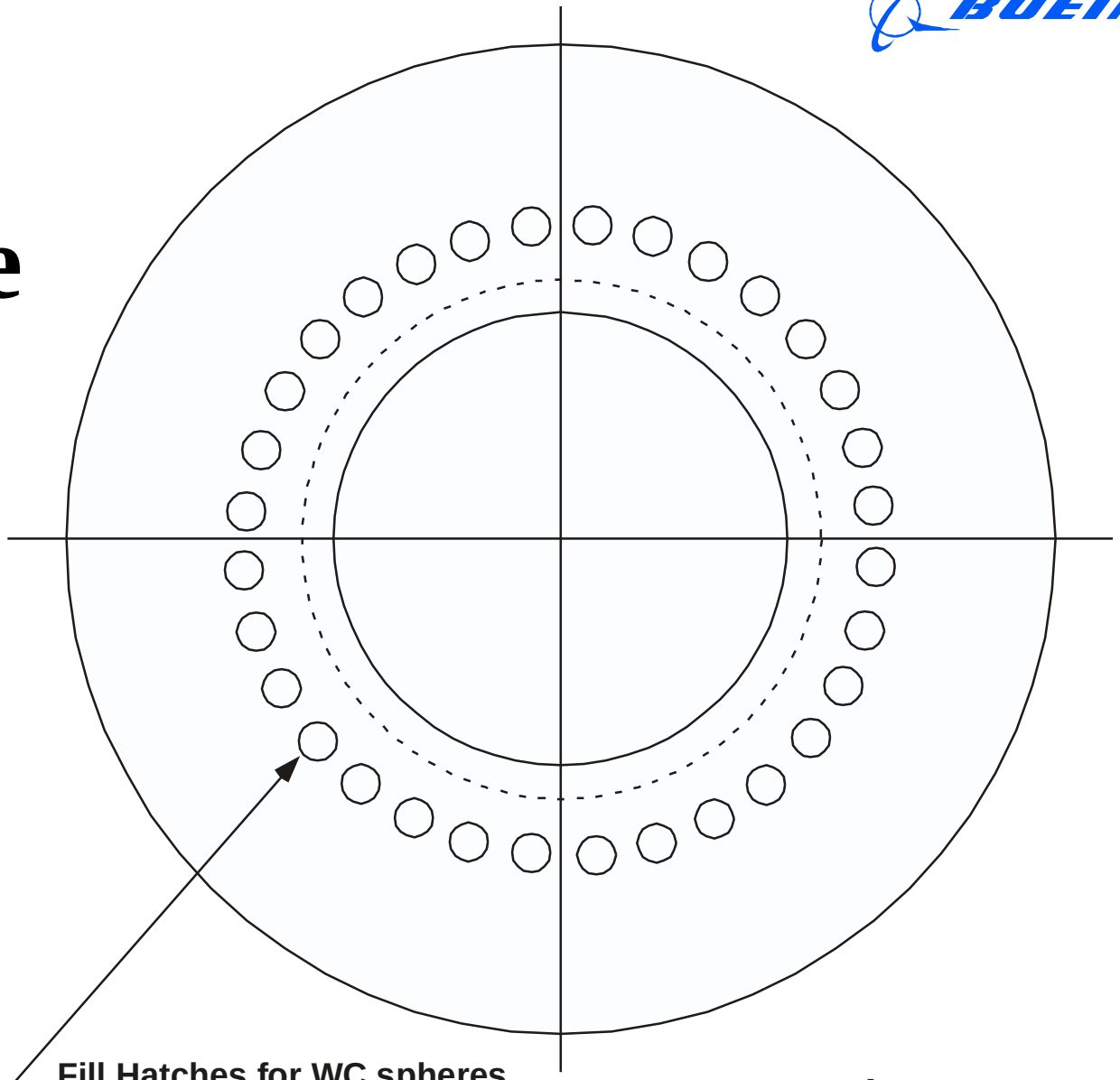
# Basic Structure with Fill Hatches



Fill Hatches for WC spheres, 50 cm diameter, 32 required, welded at final assy

Top View



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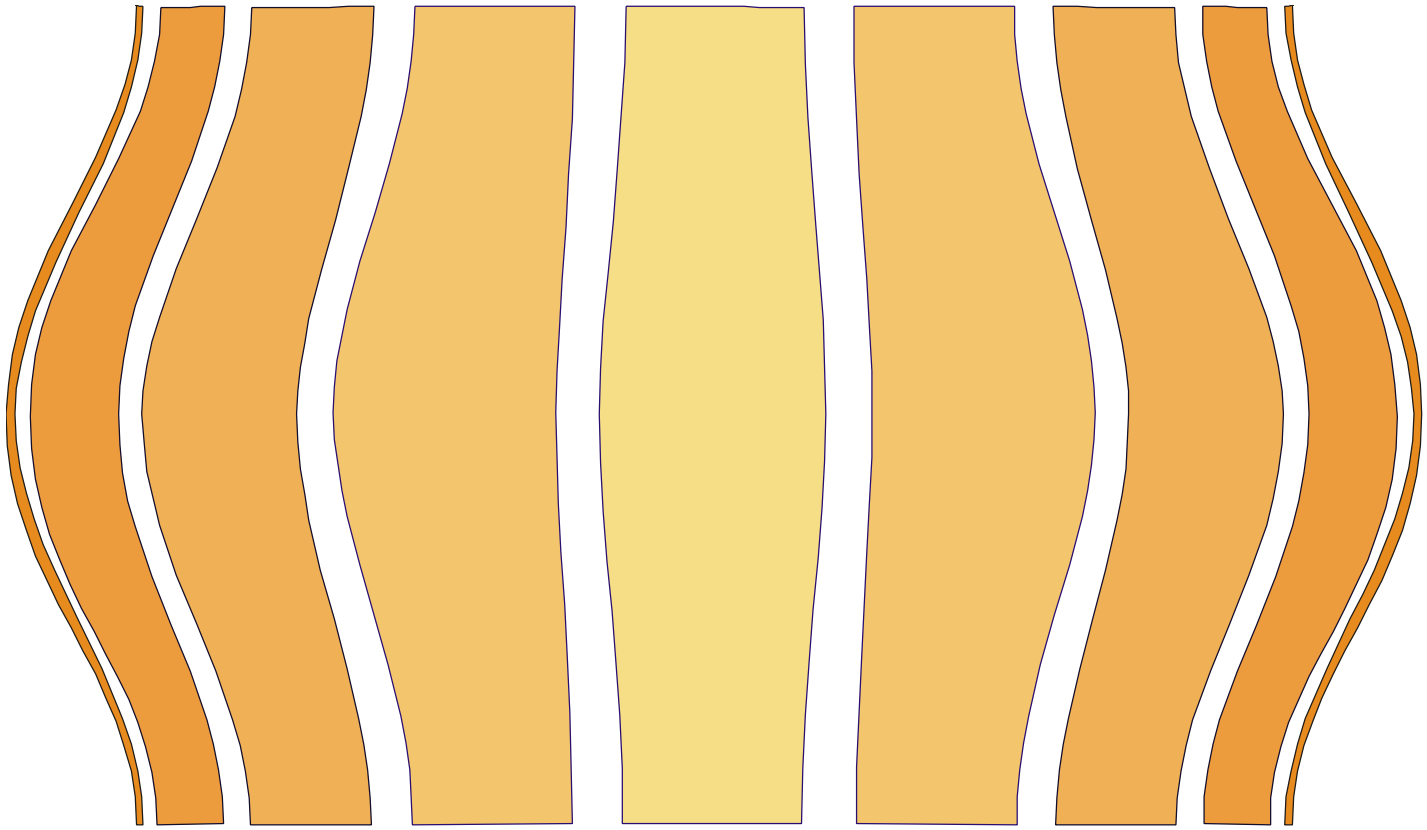
# Exterior Elevation View of Doors



Exterior Elevation View of Doors



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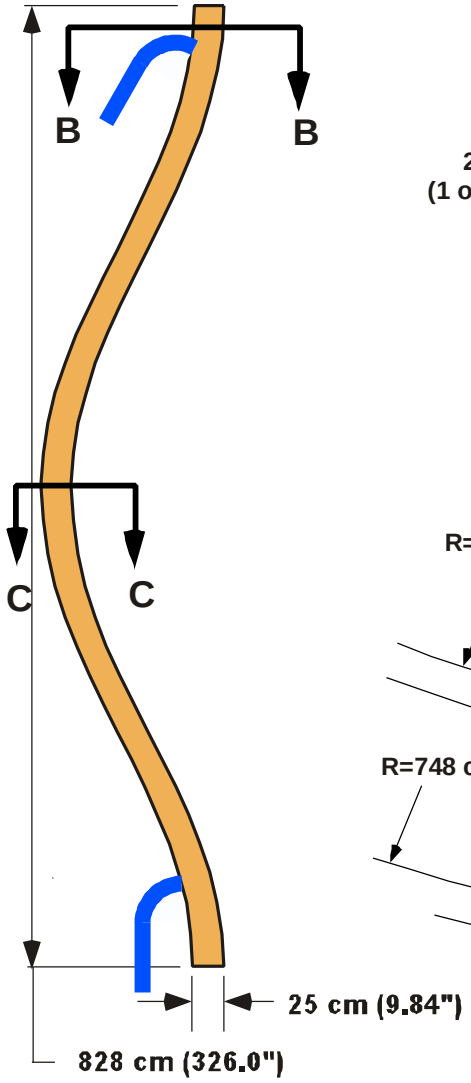
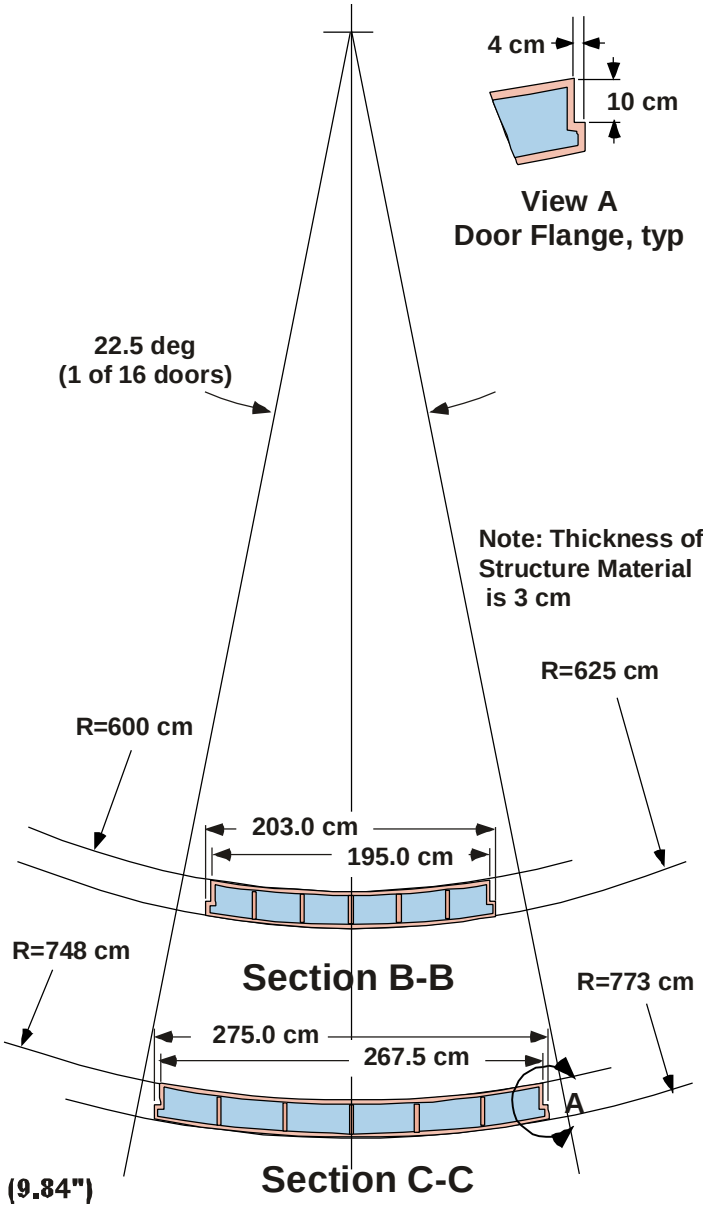
# Door Details




Door Side View




Door Cross-sections

**Fabrication costs are reduced by using an extruded Z-section* for both the doors and frames and explosively-formed** door panels**

* U. S. Profiles
** High Energy Metals, Inc



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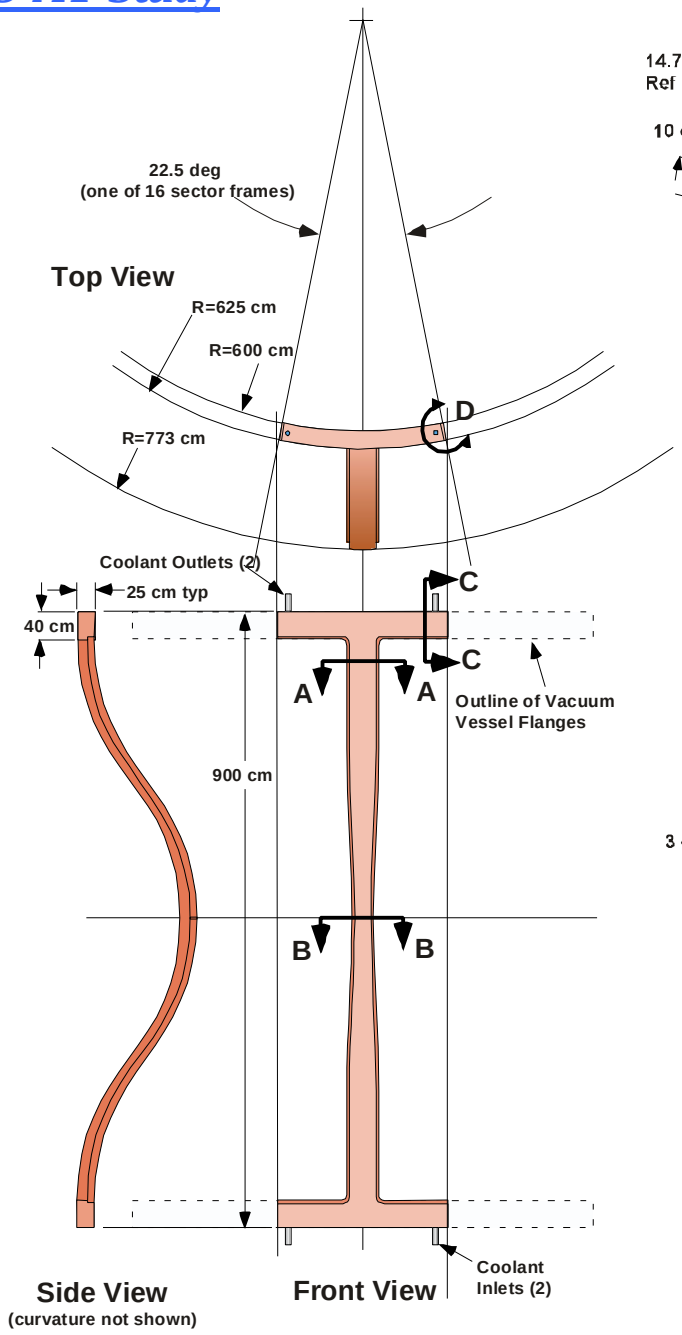
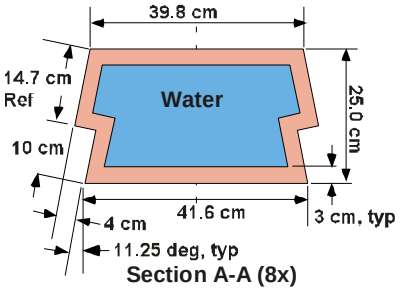
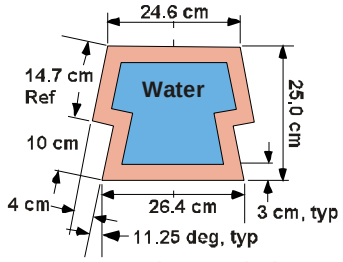
# Door Frame Details

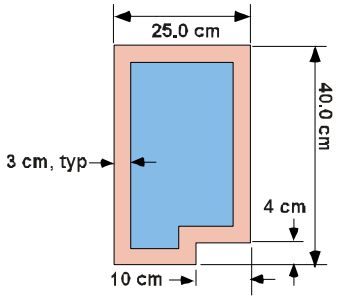


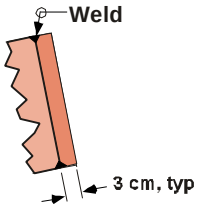

Section A-A (8x)
Frame Cross Section
at Top and Bottom




Section B-B (8x)
Frame Cross Section
at Midplane




Section C-C (8x)
Frame Cross Section
across Top and Bottom




View D (8x)
End Weldment (4 places)

- Constructing the frame in the I-shape improves the strength and reduces field welds
- Once-through cooling has highest velocity at mid-plane in highest heat flux zone



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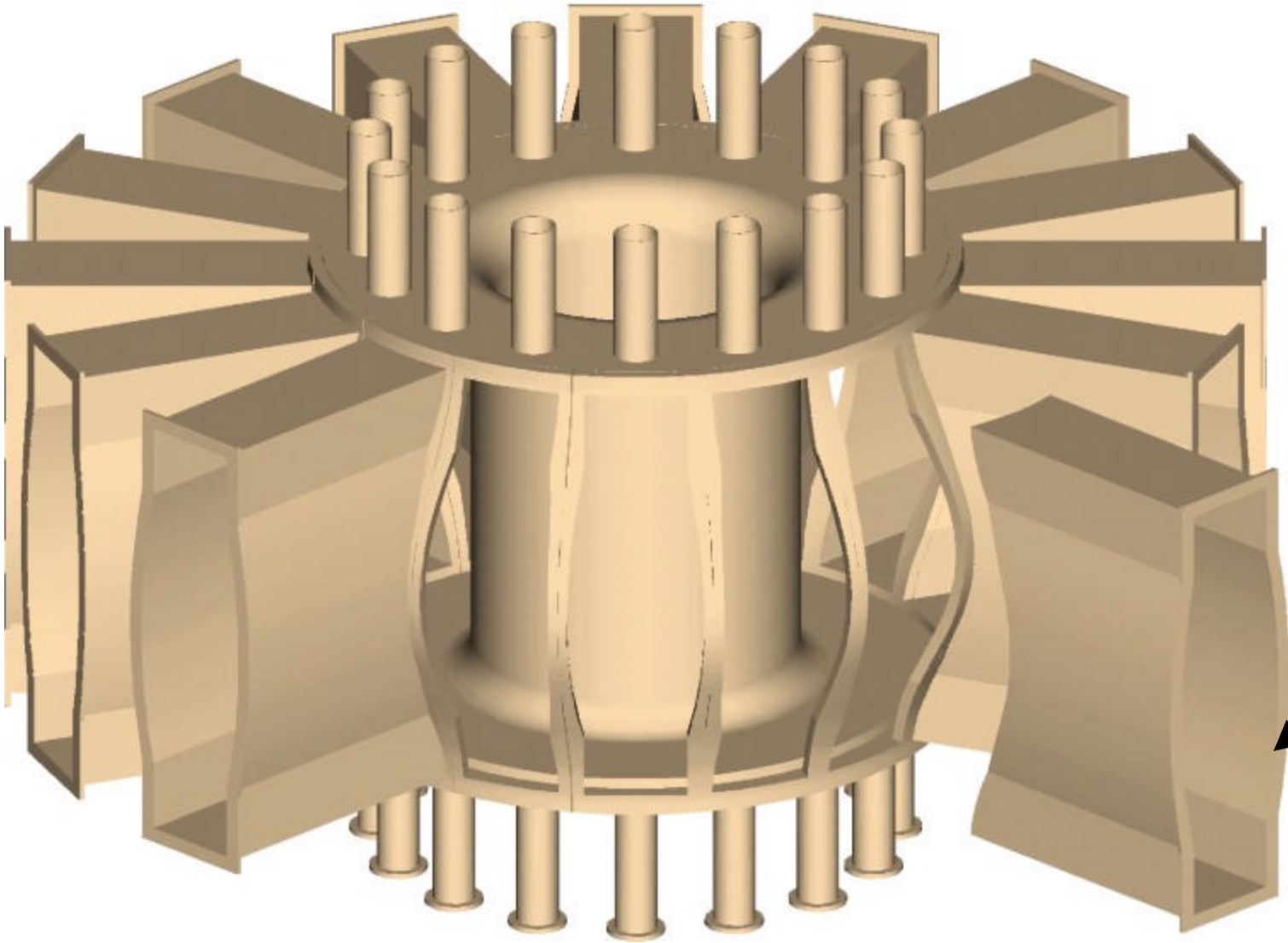
# Vacuum Vessel and Port Enclosures



**Enclosures are 10-cm-thick, double-walled structures with water cooling between 2-cm thick plates**



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# Summary of Component Masses

| Component | Mass*, Each | Mass*,Total |
|---|---|---|
| Spool Assembly | - | 136,043 kg |
| Removable Doors | 13,208 kg | 211,328 kg |
| Door Frames | 3,352 kg | 53,632 kg |
| Port Enclosures** | 44,528 kg | 712,448 kg |
| Total | | 1,113,451 kg |

- Spool Assembly and Port Enclosures are 2 cm thick
- Doors and Door Frames are 3 cm thick

* Structure only
** With outer port doors

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# ROM Cost Estimate

| Component | Total Mass | Matl Cost | Fab Cost | Total Cost |
|---|---|---|---|---|
| Spool Assembly | 136,043 kg | $493,430 | $ 2,614,897 | $3,108,327 |
| Removable Doors | 211,328 kg | $859,863 | $ 6,241,880 | $7,101,743 |
| Door Frames | 53,632 kg | $356,555 | $ 2,736,320 | $3,092,875 |
| Port Enclosures | 712,448 kg | $2,020,698 | $ 14,309,096 | $16,329,794 |
| Totals | 1,113,451 kg | $3,730,546 | $25,902,193 | $29,632,739 |
| | | | Contingency (20%) | $5,926,548 |
| | | | Prime Contractor Fee (12%) | $3,555,929 |
| | | | Total Subsystem Cost | $39,115,216 |

## Unit Costs

| | |
|---|---|
| Spool Assembly | $30/kg |
| Removable Doors | $44/kg |
| Door Frame | $76/kg |
| Port Enclosure | $30/kg |
| Composite Rate | $35/kg |



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# Discussion of Cost Items

- Tooling costs not included (10th of a kind assumption)
- Fabrication costs dominate (87%)
  - Innovative design approaches would lower cost
- Welding dominates the fabrication cost (69%)
  - Reduce welding of components
- Interior bulkheads represent most of cost (52%)
  - Integral, stiffened structures would reduce cost
- Port enclosures are a major cost element (55%) - they need to be redesigned to reduce cost.
  - Use common, larger port enclosure
  - Single-walled enclosures might be possible