# FIRE Costing Issues

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# Question 1: "Divertor costs seem appropriate at $38.24 M, but First Wall, Blanket, and Reflector Seem Somewhat Low at $20.68M. Including the Baffle at $14.15 M helps the comparison."

Answer 1: The comparable components in FIRE are the first wall tiles. The first wall consists of Be coated Cu tiles bolted to the copper clad VV wall. Based on a detailed cost estimate, we believe these costs are realistic.

**FIRE FW Estimate**

| | |
|---|---|
| Amor type | PS-Be |
| No. modules | 284 |
| Module m^2 | 0.1 |
| Yield | 90% |
| Starting matl. Cost, $K | 1021 |
| Reoccuring fab cost $K | 5959 |
| Armor joining cost | 1028 |
| Total reoccuring cost $K | 8008 |
| Unit Matl, cost $K | 3.595070423 |
| Unit fab cost, $K | 20.98239437 |
| Unit armor join. cost $K | 2.1 |
| Unit armor matl. Cost | 1.5 |
| Total unit cost | 28.17746479 |
| $K/m^2 | 281.7746479 |

## Question 2: "The FIRE cryostat is a very simple structure with a minimal delta pressure requirement, but it still seems low at $2.38M."

Answer 2: Cost ratio is 57/1.

- Probably 10:1 comes from the volume differences and the other 5:1 comes from the fact that ITER has a full helium cryostat, capable of moderately high vacuum and intermediate thermal shields, while FIRE is only a nitrogen temperature cryostat, not requiring high vacuum.
- The FIRE cryostat has the Alcator C-Mod cryostat as its prototype.

## Question 3: "Machine Assembly Tooling Is Only $2.39M As Compared to $60.9M for ITER. Does FIRE Only Need Limited Tooling?"

Answer 3: Yes; only limited tooling is needed. The difference in assembly costs can be explained by the differences in size of the two machines and the differences in technology:

- FIRE's total weight is ≈ 1,400 tonnes; ITER's is ≈ 18,800 tonnes. Note that the major radius of FIRE (2.14m) is less than that of TFTR (2.52m).
- FIRE's cryostat is a simple insulating enclosure; ITER's is a vacuum dewar.
- ITER has a blanket; FIRE only has protective tiles.

Question 4: "Fuel Processing for FIRE is $4.6 M Compared to $103.5M for ITER. FIRE Processing Demands are Less, but this would only affect through-put and storage related subsystems. Atmospheric detritiation should be a big cost item. No FIRE breakdown provided."

**Answer 4: This estimate is based on relocation of the existing TFTR tritium processing system. Breakdown now provided. System includes:**

**(1) A complete Tritium Analytical and Delivery System.**

**(2) A complete Tritium Recovery and Cleanup system to process active gases,**

**- FIRE exhaust gases**

**- Glovebox gases**

**- Tritiated vent gases**

**- Mechanical pump gases**

**- Room Cleanup & emergency VV cleanup**

(Included in this system is an Isotope Separation System (Tritium Purification System) a Hydride Transport Vessel ( HTV) system, and a Scrap Gas molecular sieve deposition disposal system.)

**(3) Process, HVAC, Area, and Stack Monitors .**

**(4) Computer Control System (TRECAMS)**

**(5) Documentation & Training**

## Question 5: "The FIRE Instrumentation and Diagnostics seems to be low at $25.39M, although this is just the estimate for Phase I. ITER is almost an order of magnitude higher and it is assuming the national parties will supply all exo-power core diagnostics at no cost to ITER."

**Answer 5: The diagnostics are costed according to US rules, only startup diagnostics are to be included in the TPC**

1) **The full cost estimate for FIRE plasma diagnostics is ~$138M made up of ~$29M for the phase I diagnostics and engineering design at the tokamak interface (included in the TPC), ~$90M for the more advanced sets to be installed in the first four years of operation, and ~$18Min R&D considered essential to successful diagnostic fabrication and operation.**

2) **The estimates of manpower and equipment costs were made in September 1999. The rates used in the calculation are those of FY99 at PPPL. The bases of most of the individual cost estimates were those for TPX, assuming design effort equivalent to that for that device.**

***Note: The cost information shown above for FIRE is only that for plasma diagnostics. An additional estimate for the Central I&C and data acquisition computer networks and facilities of ~$21M is not included. Also the instrumentation for other device subsystems, such as coil current measurement, water flows, etc., are included elsewhere within the FIRE subsystem cost estimates.***

## Question 6: "The FIRE Safety-Related Buildings (concrete) costs seem low at $72.58M."

**Answer 6: There are significant differences in the safety related buildings of the two experiments:**

- **ITER has 2 leaktight concrete vaults inside the confinement building, one around the NBI and one around the primary cooling system components. FIRE does not have such a vault.**
- **ITER has a 2 m thick concrete block shielding roof over the cryostat to reduce radiation in the crane hall.**
- **The ITER building is rated to withstand a 0.2 g peak horizontal or vertical ground acceleration in a seismic event. Not decided for FIRE, site is not chosen yet.**

# Question 7: "The FIRE Water Cooling System costs seem low"

| | Capital Cost Account | ITER | | FIRE | |
|---|---|---|---|---|---|
| **4.4** | **Water Cooling Systems** | **198.1** | | **7.26** | |
| 4.4.1 | In-Vessel Cooling | 102.0 | #2.5.1 | 1.3207 | #6.3.1 |
| 4.4.2 | Vacuum Vessel Cooling/Heating | in 4.4.1 | #2.5.1 | 0.4181 | #6.3.2 |
| 4.4.3 | Auxiliary Systems Cooling, Chilled Water | 33.2 | #2.5.3 | 3.8386 | #6.3.3 |
| 4.4.4 | Heat Rejection System | 62.9 | #2.5.2 | 1.6796 | #6.3.4 |

Answer 7: ITER's fusion energy that must be rejected is 53 times higher - 400 MW for 400 s compared to FIRE's 150 MW for 20 s.