Liquid Wall Thickness, Life, Pumping Power, COE trade-offs

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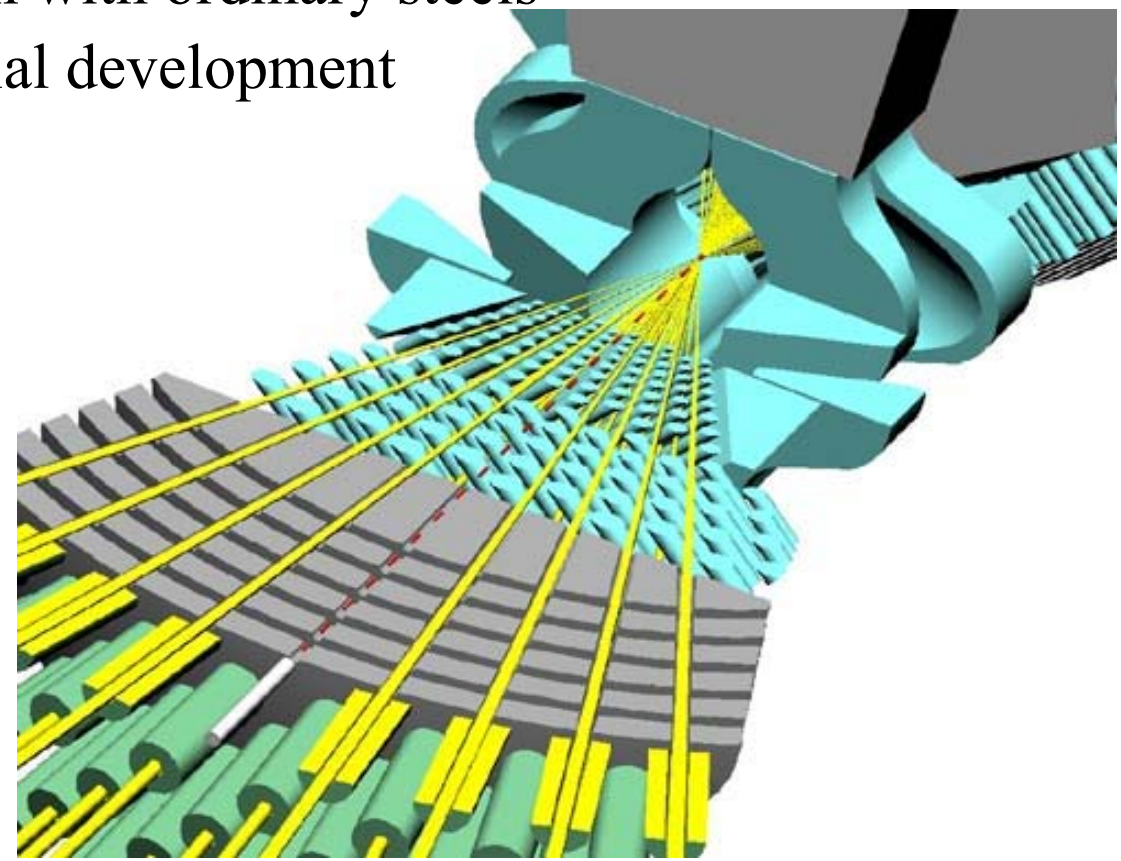
ARIES Meeting
Oct. 2-5, 2002
PPPL

Overview

- HYLIFE-II design goals
- Examining COE for
  - Reduced liquid shielding thickness
  - Lower radiation damage limits

It keeps going and going and…

- HYLIFE-II design goals:
  - Protect solid structures for full plant life
  - Low activation with ordinary steels
  - Reduce material development needs



A blasphemous question

- What is the impact on COE of reducing the liquid wall thickness resulting in reduced first wall life and the need for periodic replacement?
- Reducing liquid shielding thickness and wall life competing effects:
  - (+) Reduces pumping power
  - (+) Reduces cost of circulating pumps
  - (-) Reduces plant capacity factor
  - (-) Increases remote maintenance equipment cost
  - (-) Increases component replacement cost

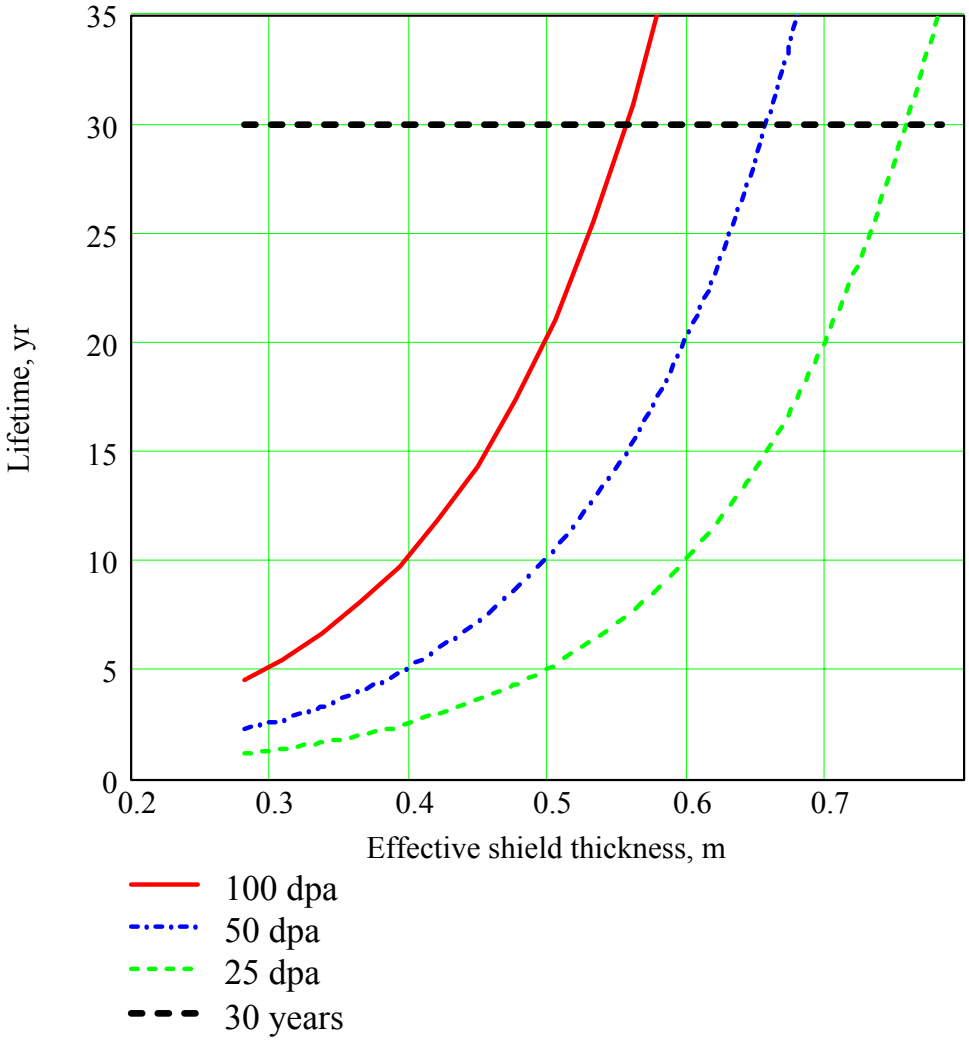
Assumptions / Approach

- Detailed model of flow rate and pumping power as function of effective shielding thickness (= geometric thickness of liquid pocket × 50% liquid packing fraction) was used
- Cost for recirculating pumps proportional to total flow rate
- Remote maintenance costs increased by 50% ($100M → $150M direct cost)
- Capacity factor as a function of FSW life and replacement time
- First wall replacement cost = $22M (½ cost of entire chamber)
- Other annual O&M costs proportional to plant capital cost (3% of direct cost, standard fusion costing assumption)

Base case parameters

- 0.56 m effective thickness (1.12 m at 50%)
- 58 MWe pumping power
- 30 yr wall life (no replacement)
- 85% capacity factor based on normal plant maintenance requirements

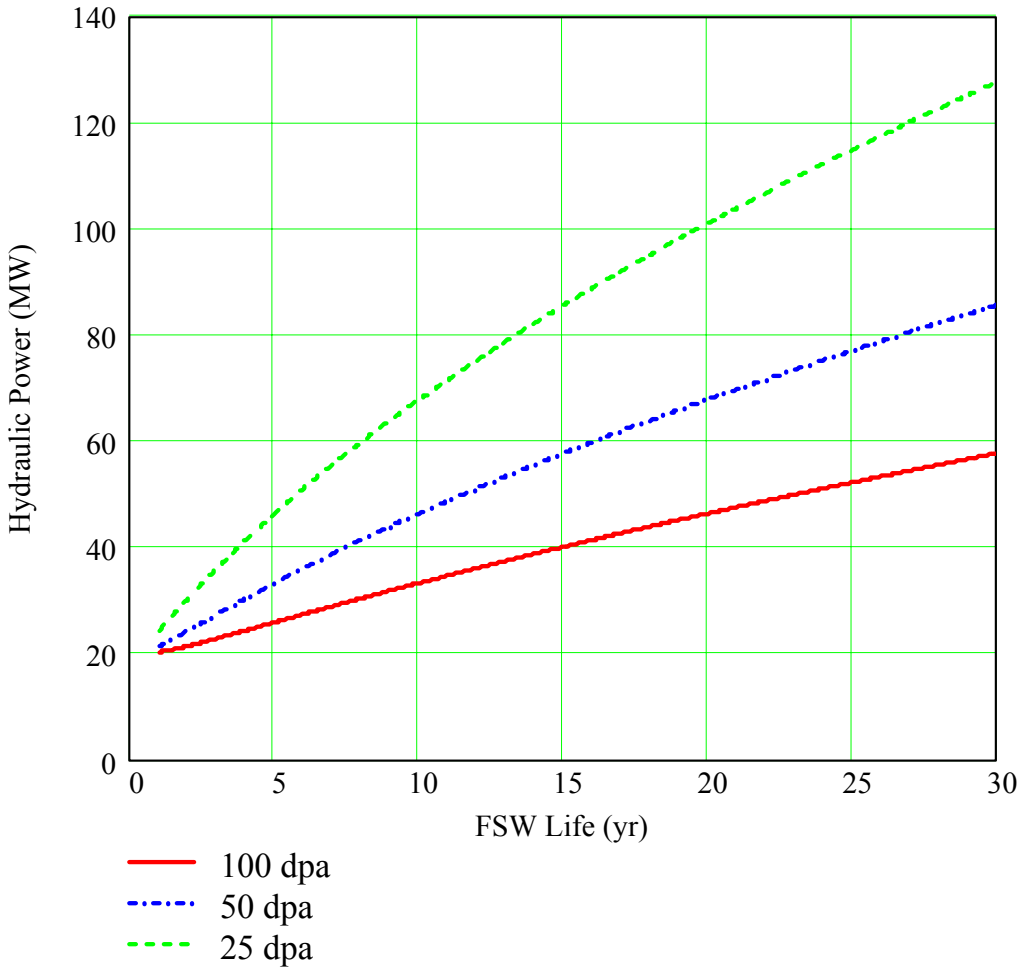
Wall life vs. shielding thickness



Base case
100 dpa limit:
0.56 m→ 30 yr
0.40 m→ 10 yr

25 dpa limit:
0.76 m→ 30 yr
0.60 m→ 10 yr

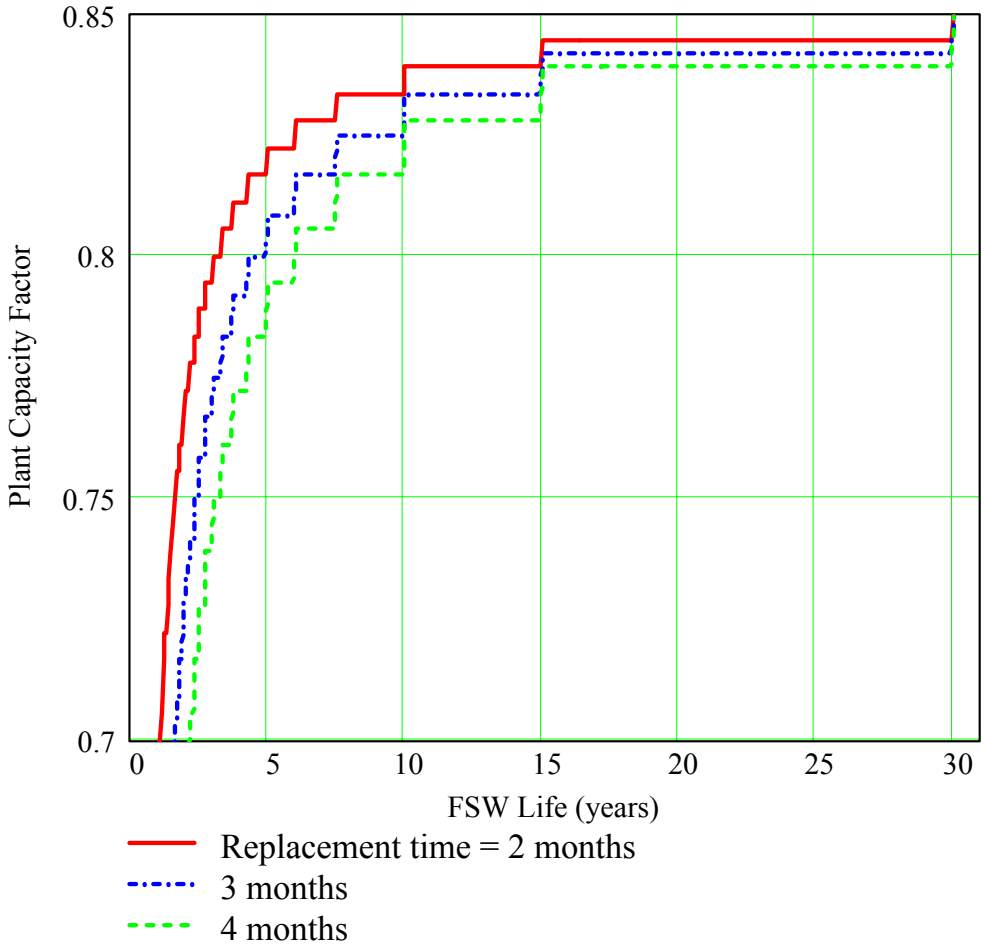
Pumping power vs. FSW life and dpa limit



25 dpa limit:
30 yr → 128 MWe
10 yr → 68 MWe

Base case
100 dpa limit:
30 yr → 58 MWe
10 yr → 33 MWe

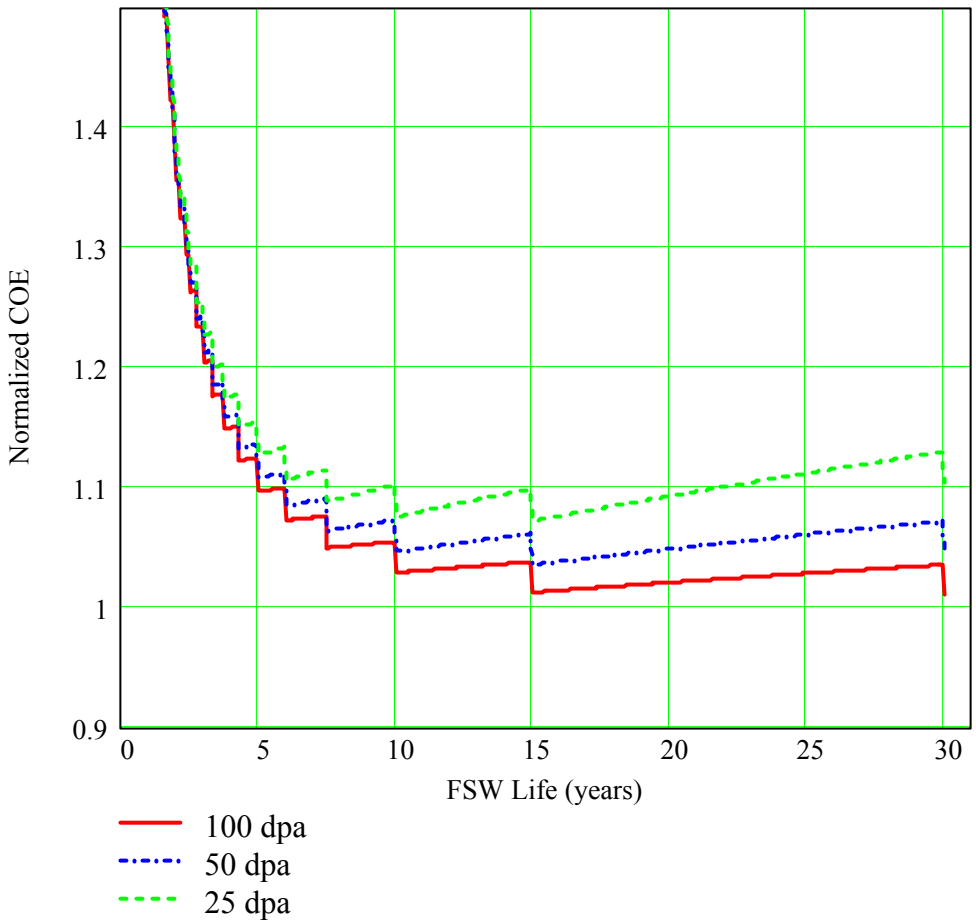
Capacity factor vs. first wall life and replacement time



Note:
-Model assumes any life between 15 and 30 yrs requires 1 FW replacement

- We assume replacement time of 3 month in following results

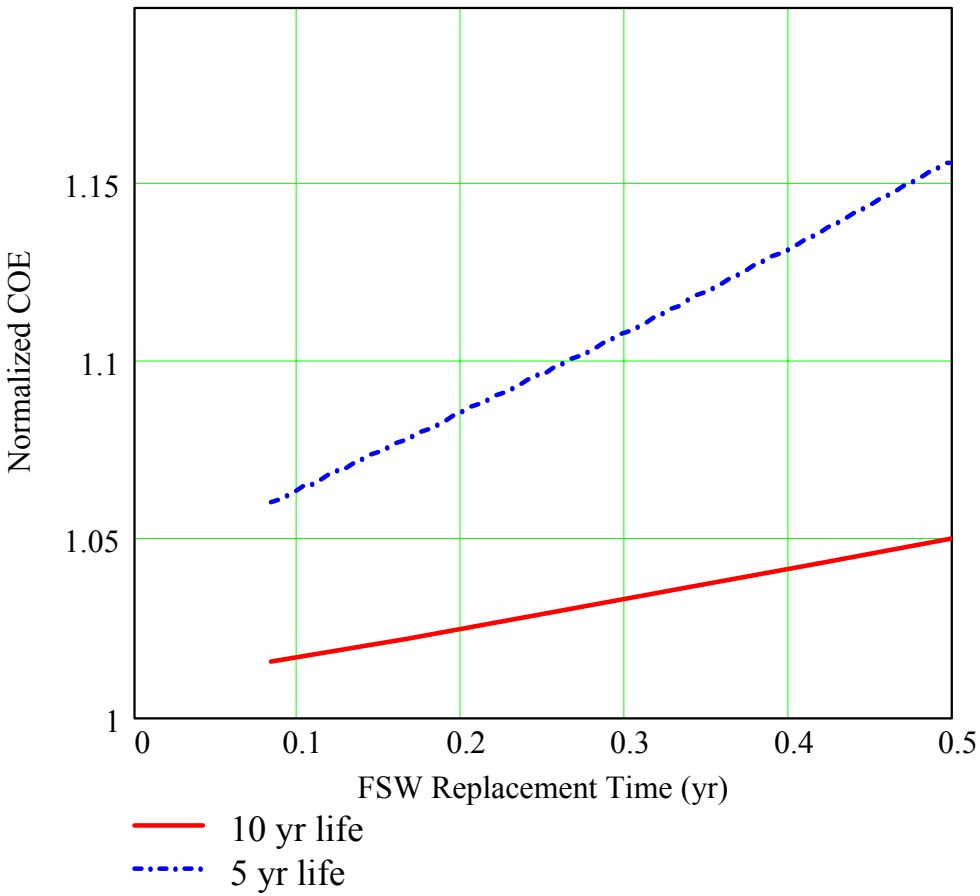
COE vs. FSW life for different damage limits



- 100 dpa limit:
>10 yr life gives COE
within ~ 4% of 30 yr case

- 25 dpa limit:
30 yr → COE +10%
10 yr → COE +7.5%

COE vs. replacement time for 5 and 10 yr wall lifetimes



- If wall lasts 10 yrs and takes 6 months to replace, COE only increases by 5%.

- But that may exceed acceptable plant down time for utility.

Conclusions

- COE effects due to decreasing liquid shielding and/or radiation damage limits have been examined
- Using current cost scaling models, 30 yr life does give minimum COE. However, wall life >10 yr have < 4% increase in COE for 100 dpa limit.
- With lower damage limit of 25 dpa, COE increase by 7.5-10% for wall lifetimes of 10 and 30 yrs, respectively.
- What is “marketing” value of 30 year chamber?