XP1000 LLD Results & Next Steps

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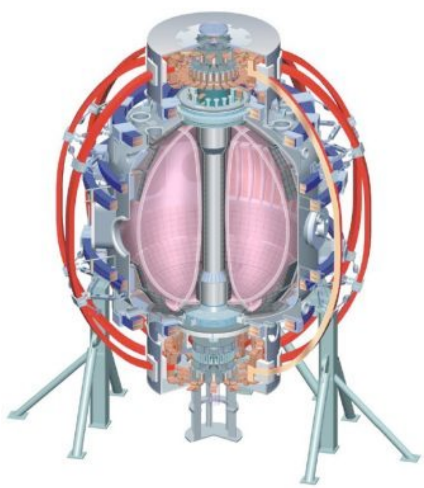
and the NSTX Research Team

LRTSG Meeting
B-318, 2PM, April 14, 2010



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XP1000 Partial Daily Outline

- Fri., 02APR10 started XP1000 Part 1B, R=50cm, LLD 220°C.
  - LLD 220°C, Did IR and Phantom calibrations
  - OSP control development
  - 3 ref at 2, 2MW and 3MW, raised LLD to 250°C
- Mon., 05APR10 returned to 02APR10 conditions, LLD 220°C
  - OSP control development, R=50, 63 cm
  - Reduced Dα relative to 02APR10
- Tue, 06APR10, LLD rm temp, 250°C
  - OSP control development R=50, 63 cm
  - LLD @rm temp. Recovered ELM-free H-modes at R=35cm
  - At R=50cm, improved OSP, increased front-end fuelling, reduced NBI
  - Obtained ELM-fee H-mode flattops
- Wed., 07APR10, LLD 320°C
  - OSP control development, R=50, 63 cm
  - LLD raised to 320°C
  - Little change in core n_e and edge T_e and n_e profiles
  - Less flux consumption early in discharge
- Thu., 08APR10, LLD 320°C
  - OSP control development
  - LLD raised to 320°C, R=63cm , 70-71cm
  - SGI test at 320°C, R=71cm
  - Lowered LLD from 320°C to 220°C

XP1000 Preliminary Partial Summary

1. 79.3 g Li deposited on lower divertor region; 5.5 g deposited on LLD.
2. Then, lithium depositions on the LLD with temperatures ranging from room temperature to 220°C were started using the LITER system at a rate of 20-40mg/min.
3. When the LLD was heated above melting, the outgassing of D increased significantly indicating perhaps the effect of fuel and/or impurity accumulation from previous operations and/or the need for additional conditioning procedures.
4. As lithium deposition increased, reproducible, ELM-free, H-mode, flattops were obtained with outer strike points at major radii of R=0.35m (near center stack), R=0.50m (mid inner divertor) and R=0.63m (the outer divertor tile ring just inboard of the LLD and outboard of the CHI gap).
5. The ELM-free, H-mode, flattop conditions were obtained using :
   - improvements in the outer strike point control,
   - optimizing fueling in the early discharge,
   - and reducing NB power as lithium deposition increased
6. LLD characteristics at temperatures up to 320°C were measured at these radii and in a return to 220°C.
7. Although slight reductions were observed in the central and edge densities, no strong pumping due to the LLD was found at temperatures of up to 320°C, with strike points out R=0.70m and the initial LLD surface conditions.
8. These ELM-free discharges, however, exhibited noteworthy reproducible energy confinement times of 100 ms and reduced flux consumption early in these discharges.

Filling LLD to 50-100% of Lithium Capacity Gives Highest Probability of Observing Pumping Effectiveness of Liquid Lithium

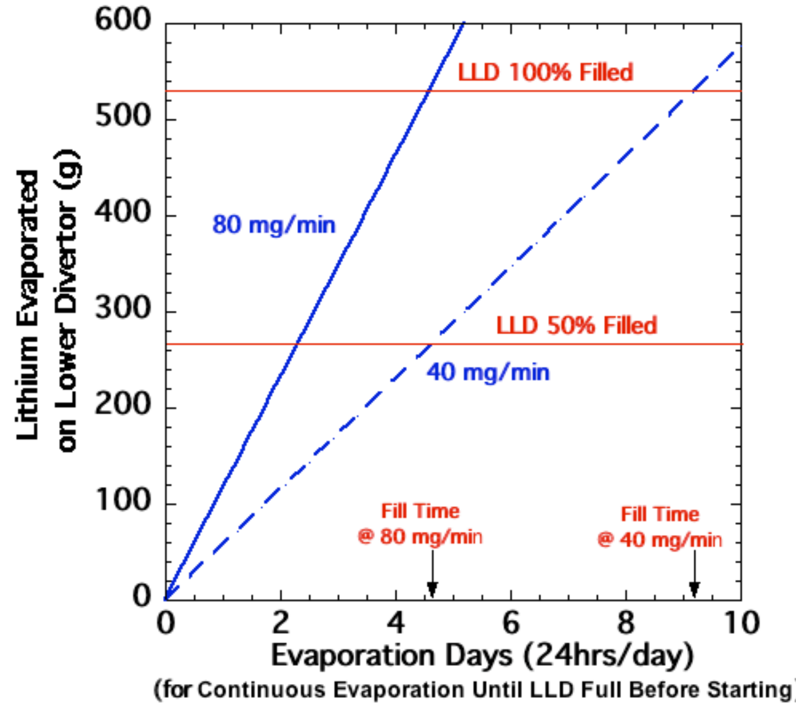
- Filling LLD to >50% Li capacity decreases the physical to geometric area ratio and by passes or minimizes 5 issues:
  - desorption of deuterium exacerbated by the high surface-area of the porous Mo,
  - mass-limited diffusion into the Li,
  - mass-limited retention,
  - effective range uncertainty.
  - Li to impurity ratio higher
- Filling LLD >50% using LITER requires many work shifts (next slide).
- Testing the LLD after filling to >50% capacity can be done in 2 ways

Start XP w/cold LLD	***Start XP w/220°C LLD***
• Fill 50% @220°C • Cool to RmTemp (RT) • Keep LITER on • Do controls tuning • Degas to 320°C, then cool to RT • Do R=70cm • Do Tile + LLD pumping • Turnoff Tile pumping and test duration of LLD pumping	• Fill 50% @220°C. • Keep at 220°C • Keep LITER on • Do controls tuning • Degas to 320°C, then cool to 220°C • Do R=70cm • Do Tile + LLD pumping • Turnoff Tile pumping and test duration of LLD pumping

LLD Fill Times for Next Step

- LLD Li capacity = 37 g.
- Required LITER deposition for fill =527 g (using 7% efficiency)
- 160g per LITER refill cycle (@80g/per unit)

%Fill	Hours	Rate (mg/min)	2 Shifts per day	3 Shifts per day
50	110	40	6.9	4.6
	55	80	3.4	2.3
100	220	40	13.8	9.2
	110	80	6.9	4.6



Pros and Cons of Two LLD 50% Fill Scenarios

• Fill 50% @220°C • Cool to RmTemp • LITER on • Do controls tuning • Degas to 320°C; cool to RT • Do R=70cm • Do Tile + LLD pumping • Turnoff Tile pumping and test duration of LLD pumping	• Fill 50% @220°C. • Keep at 220°C • LITER on • Do controls tuning • Degas to 320°C; cool to 220°C • Do R=70cm • Do Tile + LLD pumping • Turnoff Tile pumping and test duration of LLD pumping	Issues
• Saturate before ready. Need to raise to 320°C to degas and cooldown for Rm temp case. • Carbon and oxygen.	• Need to raise to 320°C to degas & cooldown for 220°C case Start taking R=70cm immediately after controls tuning.	• Finite N_{li} • Impurities on surface • Li to impurity ratio
• Physical erosion of Li lower at Rm temp. This may slow impurity removal?	• Sputter yield of Li (and possibly impurities) increases with temperature.	• Using OSP sputtering to expedite cleanup after controls tuning.
• Could require considerable time to dissolve sat. layers acquired during cntrls tuning.	• No layer to dissolve. Surface ready for the XP faster.	• Diffusion time to dissolve LiD at 300°C • Estimates vary by ~x10^5
• Need extra cycle. cold+320+cold+220+320+cold	• 220+320/320+220+cold	• Schedule and efficiency