

## LLD Meeting, 3/08/07

- Agenda:

Progress Toward the Design Goals and the Process - H. Kugel

Physics Considerations for the Design of the Liquid Lithium Divertor for NSTX - R. Maingi

Semi-Analytic Predictive 0-D Modeling of Pumping Schemes for NSTX - R. Maingi

- Attendees:

L. Zakharov, L. Roquemore, R. Maingi, D. Stotler, F. Jones, C. Skinner, B. Stratton, R. Kaita, D. Mansfield, E. Fredrickson, M. Ono, C. Bush, J.-W. Ahn, V. Soukhanovskii, E. Mazzucato, B. LeBlanc, K. Tritz, K. Williams, H. Kugel.

Editors: H. Kugel, R. Kaita, R. Majeski, R. Maingi

- Meeting comments from the Attendees and post meeting comments from R. Majeski

- Comments on "Progress Toward the Design Goals and the Process - H. Kugel"

1. C. H. Skinner: In Slide 2, re Proposed Physics Design Goals, distinguish between the two listed inductionless current drive density targets as "Option 1" and "Option 2". Under Geometry Design Goals include "4) Orientation (horizontal or sloped) and nesting (on tile or on copper PP)".

2. C. H. Skinner: In the Table in Slide 4, re the Erosion and Deposition Issues column, it would be timely to obtain the W. Wampler (SNL) tile analysis results for the 4/15/07 decision, and prior to the visit of J.-P. Allain (ANL) at the end of March.

3. D. K. Mansfield: Recommended filling LLD using lithium powder rather than hypodermic needle fill probes. (Comment from R. Kaita after meeting: fill probes will be similar to units used on CDX-U which had 1/4" OD "squirt tubes" instead of "hypodermic needles.")

R. Majeski: The "hypodermic needle" is really a reference to the syringe-like filling system. Any filling system MUST be demonstrated; the demonstration must include wetting of the tray structure by the lithium introduced by the fill system.

4. R. Maingi: Tile instrumentation requiring relocation could be installed in special tiles mounted in gaps of sufficient width between the LLD segments. (Comment from R. Kaita after meeting: not all tile instrumentation displaced by LLD needs to be relocated, e. g., high-temperature 3-axis magnetic sensor [1] to be tested in NSTX in FY08 run can be placed underneath LLD for equilibrium reconstruction measurements and combination of LLD thermocouples and IR imaging can replace tile thermocouples.)

• Comments on "Physics Considerations for the Design of the Liquid Lithium Divertor for NSTX - R. Maingi"

1. L. Zakharov: In the graphs in Slides 6,7,8 the curves will be very temperature dependent since there will be no pumping above 350°C. R. Majeski: We had no indication of a 350C temperature limit in the CDX-U experiments. All our low recycling discharges on August 18, 2005 (our last run day) were run with the tray temperature at 450C, and showed very good particle pumping. The practical limit to the divertor temperature will more likely be evaporation.

Editors: See references [2-3].

2. L. Zakharov: Re Slide 10, it is preferable to locate LLD on the inner divertor at the #1 and #2 locations. If the heat flux is high the resulting evaporation will coat the nearby Outer Divertor, acting as a lithium evaporator.

3. D. K. Mansfield: Recommended extending the proposed UEDGE calculations to include the vertical Inner Divertor.

4. L. Zakharov: It is erroneous to assume total transport along field lines to the LLD, since reduction of the density could result in about 50% of the efflux on NSTX to come from trapped energetic particles. The SOL width could be determined by fast ions at low density-consider how to handle this. (Comment from RM: the degree of this effect depends on how low the density goes. If we initially start at high density  $\sim 6.5 \text{ e}^{19}$  for our target discharges, we would have to reduce the density down to  $2\text{-}2.5\text{e}^{19}$  for the fast ion content to reach the proportion mentioned above. Nonetheless, we should determine a way to quantify this effect.)

5. C. H. Skinner: Suggested that the modeling and decision process should be iterative. R. Maingi concurred but noted that a very focused effort toward the proposed design goals will be needed to arrive at the 4/15/07 decision. In this approach, R. Maingi noted the differences between working design specs, goals, and milestones.

6. M. Ono: Use both #116313 and #121238 as starting points for the calculations.

7. V. Soukhanovskii: Determine if impurities play a role in setting the possible density reduction..

8. R. Kaita: Review the existing calculations by Brooks/Rolinilien/Maingi. [4]

Comments on "Semi-Analytic Predictive 0-D Modeling of Pumping Schemes for NSTX - R. Maingi"

1. General discussion on pumping with Strike Point centered on LLD versus pumping with the

LLD offset from the Strike Point by some distance. R. Maingi noted that in DIII-D, it was possible to vary pumping by varying the Strike Point distance from the cryopump. It was speculated that even with the LLD located near the inner edge of the Outer Divertor some pumping of ISD plasmas with Strike Points on the nearby Inner Divertor may occur. The merits of having a segmented LLD with separate temperature controls might also allow varying the effective pumping speed of the LLD. R. Majeski: True – but pumping will be inhibited on a segment only if the segment is allowed to solidify.

2. R. Maingi: Lithium pumps atomic deuterium-need to determine if this affects the 0-D model formulation? Probably not, since the DIII-D cryopump pumps molecules, but can be taken into account in the manner discussed.

#### Recommendations:

1. An LLD working meeting every week will be needed to reach the 4/15/07 Decision.

#### References

[1] H. Takahashi, S Sakakibara, Y Kubota, and H Yamada, Rev. Sci. Instrum. **72** (2001) 3249.

[2] "Deuterium retention in liquid lithium", J. Baldwin, et al., Nucl. fusion 42 (2002) 1318.

[3] Measurements of erosion mechanisms from solid and liquid materials in PISCES-B, R. P. Doerner, et al., J. Nucl. Mater., 290-293, (March 2001) 166-172.

[4] PSI modeling of liquid lithium divertors for the NSTX tokamak", J. N. Brooks, et al., J. Nucl. Mater. 337-339 (2005) 1053-1057.