



Thermal Control of the

Liquid Lithium Divertor for NSTX



Abstract: This paper describes the Liquid Lithium Divertor or LLD, its expected thermal performance, the control system and supporting analysis and experiments.

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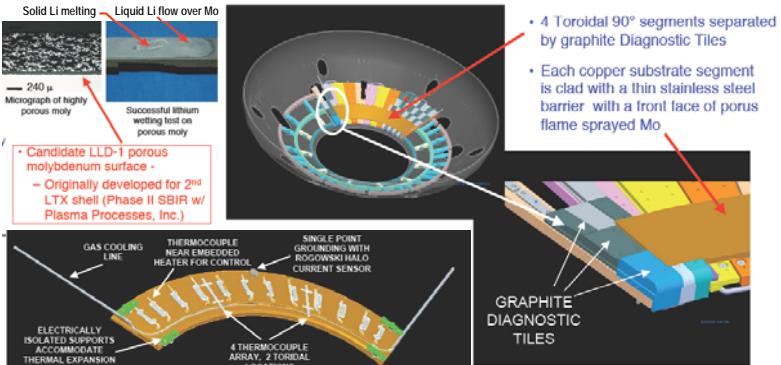
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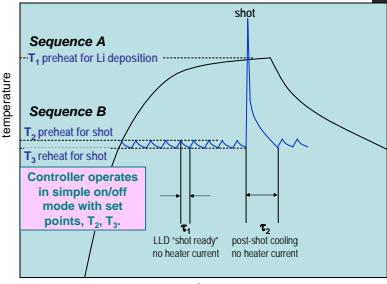
A fundamental issue in operating the LLD (Liquid Li Divertor) with the strike point on or near the LLD is to maximize the shot time while avoiding excessive evaporation of Li.

LAYOUT OF THE LLD

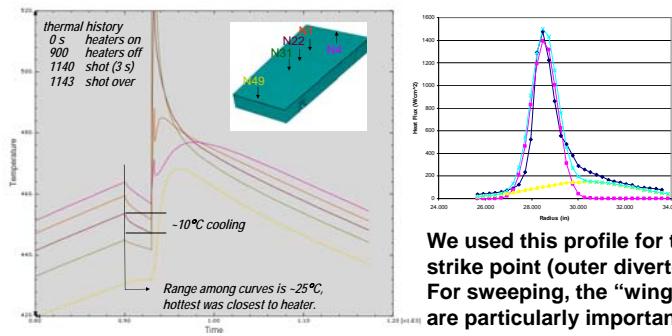
- 4 plates (quadrants)
- 22.2-mm Cu plate
- clad with 0.4 mm of SS
- flame-sprayed Mo surface
- inner radius 655 mm
- 215 mm wide
- incline 21.5°, 82.5° toroidal angle
- brazed SS He cooling tube
- center support stalk
- 12 500W heaters with TCs
- 12 control TCs near heaters
- 4 other TCs



Upgraded NSTX LITER evaporators will coat the LLD with Li.



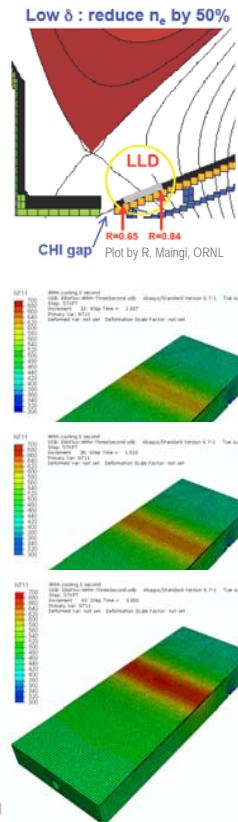
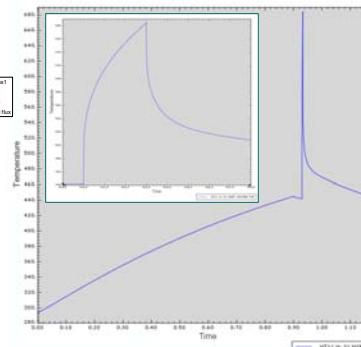
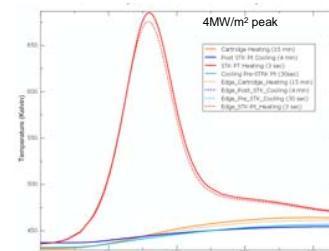
In plot at right, LLD spot cools ~10°C in 4 minute cooling step before shot.

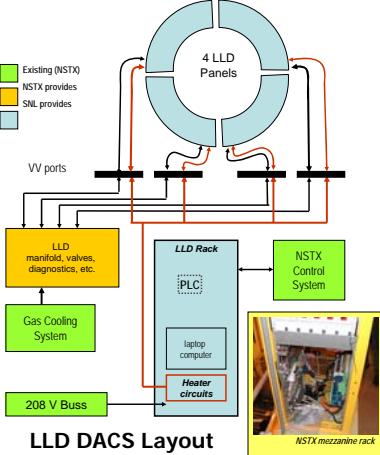


We used this profile for the strike point (outer divertor). For sweeping, the “wings” are particularly important.

BASIS FOR SHOT LENGTH

- experience with the LLD, and
- thermal analyses for various heat flux profiles.





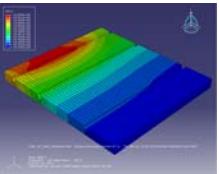
LLD CONTROL RACK (Sandia)

- power conditioning and isolation switches on two hot 208 V lines
- controller and switches for 48 heaters
- data acquisition modules for 112 TCs
- PLC and laptop computer for local control and data management
- flow control switches and pressure monitoring for He cooling lines (4).

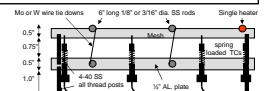
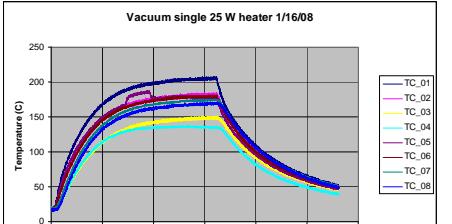
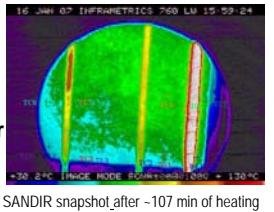
FUTURE WORK

Sandia will procure the LLD plates and prepare the control rack this fall. We will work with the NSTX team to install equipment during the NSTX vent.

INITIAL TESTS ON Mo MESH



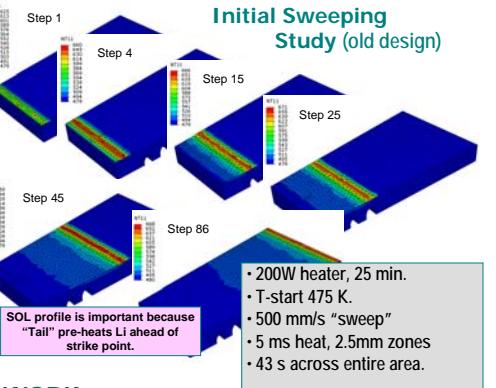
Sandia is studying a CVD Mo-coated pyrolyzed C mesh as a Li reservoir for an upgraded LLD.



THERMAL ANALYSES

- stationary on LLD
- swept across LLD
- inboard of LLD - pumps the outer SOL*
- outboard of LLD - pumps private flux region*

*longer shot times with strike point off the LLD

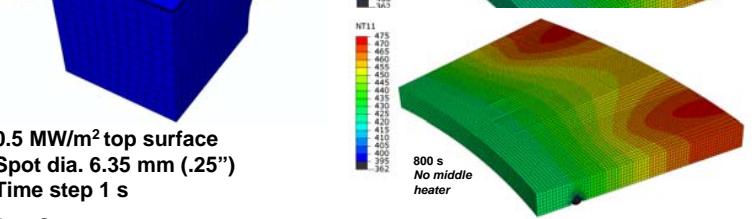
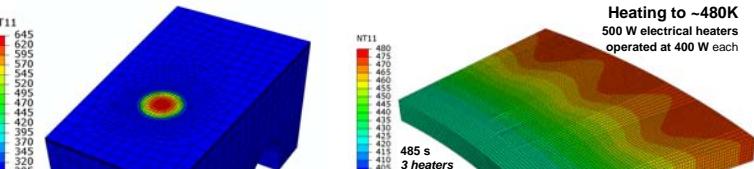


FUTURE WORK

Sandia will perform some testing of mockups with a He heat transfer system for heating and cooling of a LLD for a future application such as an upgraded LLD for NSTX and for the proposed NHTX.

We tested refractory He-cooled heat sinks built by Ultramet with an integrally bonded internal open porous mesh that very effectively enhances heat transfer.

We initially proposed a design for the LLD based on a porous Mo mesh with the added specification that the Mo be deposited over a pyrolyzed carbon skeleton. The objective was to improve the thermal conductance of the mesh material by using high conductivity carbon with a coating of Mo. The mesh also provides a reservoir of Li that would move to the surface by capillary action.



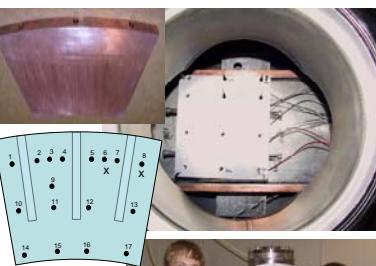
- 0.5 MW/m² top surface
- Spot dia. 6.35 mm (.25")
- Time step 1 s

Other Cases

- startup with a frozen limiter
- failed heater(s)
- braze flaws (SS/Cu)
- alignment hot spots

Cold spots (solid Li) reduce pumping but are not a problem otherwise.

Flaw analysis guide both quality assurance during fabrication and the effects of flaws in operation.



BENCHMARK HEATING TESTS

Benchmark heating tests of a Cu plate mockup with 3 heaters is providing baseline data for our thermal modeling, as well as the load for our shakedown testing of the control rack. The model results shows cases of the mockup with one heater off and with all 3 heaters working.



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