# APEX Task I: Summary of Draft NSTX System Requirements Document for Flowing Liquid Walls

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APEX Electronic Meeting
24 March 2000

# Contributors

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# Key Issues

- 1.0 Explore the potentially beneficial effects of liquid metal walls
- 2.0 Test integrated physics-technology liquid wall issues

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# 1.1 Plasma scrape off and edge properties due to reduced (or zero) particle and impurity recycling

- Flowing liquid wall (FLW) shall function to affect profiles and decay lengths, edge turbulence, impurity control, fueling methods and efficiency, power handling, etc. to improve NSTX plasma performance

- FLW shall function to solve the problem of lithium wall heat removal by limiting lithium evaporation.

- FLW shall function to solve the problem of “refreshing” walls saturated with hydrogen.

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# 1.2 Plasma core confinement due to improved plasma edge control

- FLW shall function to affect impurity content and transport, attainment and maintenance of H-mode pedestal, changes in plasma turbulence and transport, etc. to improve NSTX plasma performance.

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# 1.3 Plasma heating and current drive efficiency

- FLW function shall be to affect changes in coupling through scrape off layer, presence of $^{7}$Li resonances, changes in radio frequency launcher, standoffs, shielding conditions, compatibility with helicity injection, etc. to improve NSTX plasma performance.

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# 1.4 Plasma stability due to presence of nearby conducting liquid layer

- FLW shall function to affect beta limits, compatibility with control of resistive wall modes, current penetration and equilibrium profile, achievement of J(r), p(r) profiles compatible with high confinement, etc. to improve NSTX plasma performance.

- FLW shall function as a mechanism for stabilizing non-axisymmetric magneto-hydrodynamic (MHD)plasma modes shall be implemented only after a theoretical basis for the stabilizing effects of poloidal liquid lithium flows has been established.

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# 2.1 Hydrodynamic response, heating & vaporization of flowing liquid under plasma heat & particle loads

- FLW's shall function to test maximum allowable liquid temperatures, modeling and extrapolations, etc.
  - Replacement of carbon tiles as the plasma facing surface with liquid lithium flowing either over them or directly on copper plates with cooling.
  - Use of some (but not all) of the feedthrough tubes on the center stack for lithium inlets and outlets.
  - Installation of a catch basin to protect the insulator between the center stack and the outer vacuum vessel.
  - Compatibility with coaxial helicity injection.
  - Restriction of divertor operation to single null.

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# 2.2 MHD characterization of techniques for establishing, stabilizing and maintaining FLW

- FLW's shall function to test plasma startup, heating, flattop, and termination and abnormal events.
  - Inlet, outflow, reservoir, and recirculation schemes
    - » Liquid lithium flow only during plasma shot.
    - » Liquid lithium drain & pumping between shots.
  - Discharge initiation, control, and termination scenarios
    - » Sensors behind a flowing conducting liquid.
  - Requirements for plasma control, equilibrium reconstruction, and physics measurements shall be satisfied.

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# 2.3 Development of diagnostics and instrumentation techniques

- FLW's shall function to test combined liquid wall-plasma electromagnetic diagnostics, sensors for liquid wall material conditions and migration, etc.
  - Develop nozzle designs, penetrations, and other flow considerations.
    - » Flowing liquid walls shall accommodate penetrations for heating and drive systems and diagnostics.
    - » Flowing liquid walls shall not interfere with heating and current drive systems (including coaxial helicity injection), diagnostics, and configuration flexibility.

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# 2.4 Environmentally safe LW systems, handling procedures & accident prevention techniques

- FLW's shall function to test management and containment of liquid metal, effects on diagnostic equipment and access, accident prevention, fail-safe and protection systems, etc.

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# Summary

- APEX program will develop and provide liquid wall technology systems that satisfy a set of operational conditions before installation in NSTX.
- Flowing Liquid Wall-in-NSTX (FLW-in-NSTX) WORKING GROUP will address and recommend in the near future what these operational conditions should be.
- FLW-in-NSTX WORKING GROUP will also address and recommend concept exploration (CE) level physics and technology tests required to demonstrate these conditions.

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# Summary (continued)

- NSTX could become a device to implement FLW capabilities that satisfy the operational conditions and contribute to the 10-year objective identified by FESAC of demonstrating spherical torus attractiveness over long pulse durations.

- Time  frame for possible implementation of FLW capabilities in NSTX is about five years.

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