UCLA Experimental Plans and Capabilities in Thermofluids Research

Related to Subtask 3-1 of the DOE-Monbusho Collaboration Proposal

Responsible persons:

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Japan Monbusho / US DOE Collaboration
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Thermo-fluid capabilities at UCLA

Laboratory Thermofluid Facilities

- **Multiple flow loops**
- **Multiple magnets and high current power supplies (from PPPL and MIT)**
- **High bay space and high load crane**

Special materials handling capabilities (Be, Flibe)

- **Glovebox and enclosure facilities**
- **Approval for large scale Be handling (PISCES and Solid Thermomechanics experiments)**
- **Flibe qualification underway for vaporization/condensation experiments for IFE**

UCLA Capabilities (Continued)

Thermofluid Instrumentation
- Laser doppler velocimetry
- Micrometer & ultrasonic flow depth probes
- Bubble/dye flow visualization and fast digital photography
- Holographic temperature profiling

Computational Tools
- DNS/LES/MHD codes
- Free Surface Codes
- Parallel computing clusters and data visualization laboratory

Interested UCLA faculty with worldwide reputations

- Vijay Dhir: Fluid heat transfer
- John Kim: DNS and MHD
- Robert Kelly: Free surface flow
- Nasr Ghoniem: Fusion materials

UCLA Fusion Science and Technology Group experience
- Magnet design and construction
- Thermofluid/MHD experimentation
- MHD/free surface modeling

Key Thermofluid Facilities Proposed for Collaboration

Fli-Hy: Flibe Hydrodynamic Simulation Facility

- Water/KOH Discharge System and High Field Magnet
- *Status: Design and Construction*

HiTeC: High Temperature Cycling Experiment

- Paratherm High Termperature, High Prandtl Organic Oil Loop
- *Status: Operating since 1993*

MeGA-Loop

- Liquid Metal Flow Loop Coupled with Large Volume Magnetic Field Facility for open and closed channel MHD experiments
- *Status: Operating since 1992, Upgrade to toroidal magnet in progress*

➢ **These operating facilities can accommodate the needs of the collaboration**

Flibe Hydrodynamic Simulation Facility, or *Fli-Hy*

Facility role: ***flexible Flibe simulant loop for a variety of hydrodynamic, magnetohydrodynamic, and heat transfer experiments for MFE and IFE***

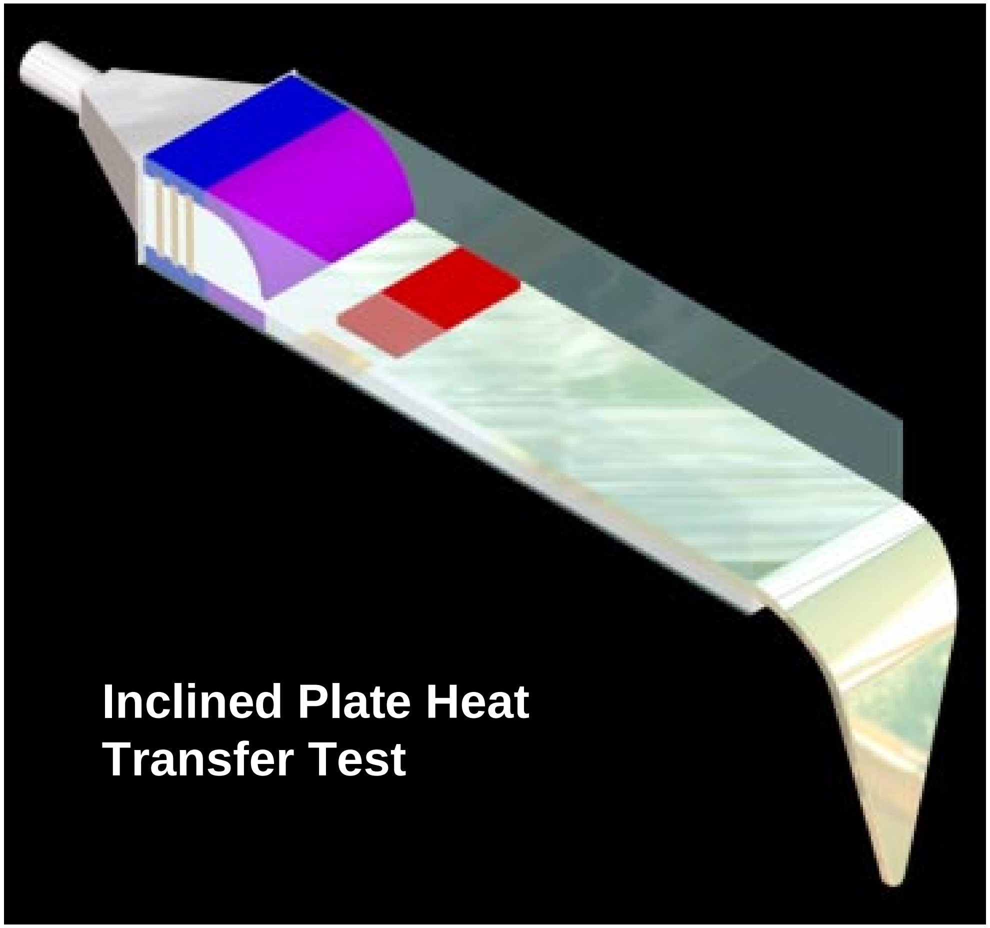
Current facility design specifications

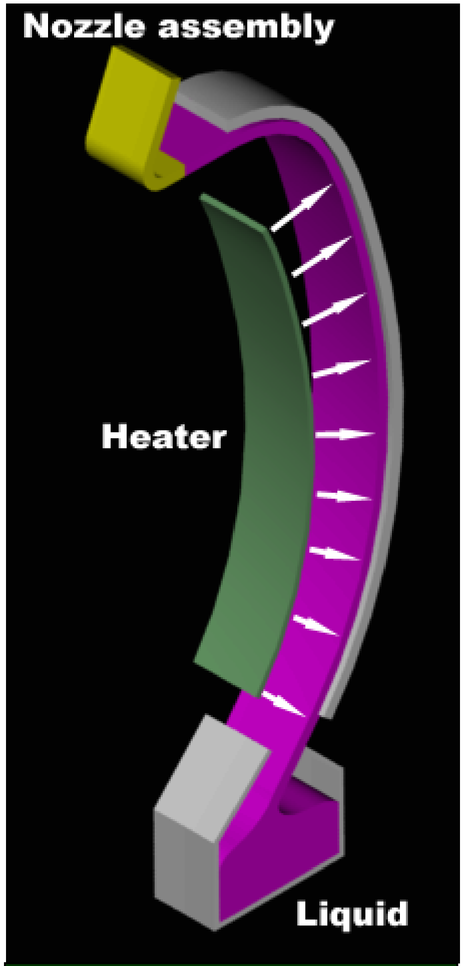
- **Switchable water or water/electrolyte working liquid**
- **Discharge or continous operating modes**
- **316SS and CPVC components for electrolyte compatabilty**
- **>2 m^3 working volume**
- **>100 l/s maximum flowrate capability (in discharge mode)**
- **>10 m/s flow velocity**
- **Temperature control from 4 to 50C**

Status:

- ➢ **Design phase underway**
- ➢ **Construction phase awaiting final design review at UCLA**

Fli-Hy Example Test Sections





Curved Plate
Heat Transfer Test

Features of Flibe Simulation with Aqueous KOH Solution

Advantages:

- Low cost for working liquid
- Low operating temperature
- Wide material compatibility and low material cost
- Large flow volumes and flow rates possible for free surface flow tests
- Transparent medium for optical flow measurements
- Scaling favors reduced size and flow velocity tests
- Relatively high electromagnetic parameters for simulation of MHD/turbulence interactions

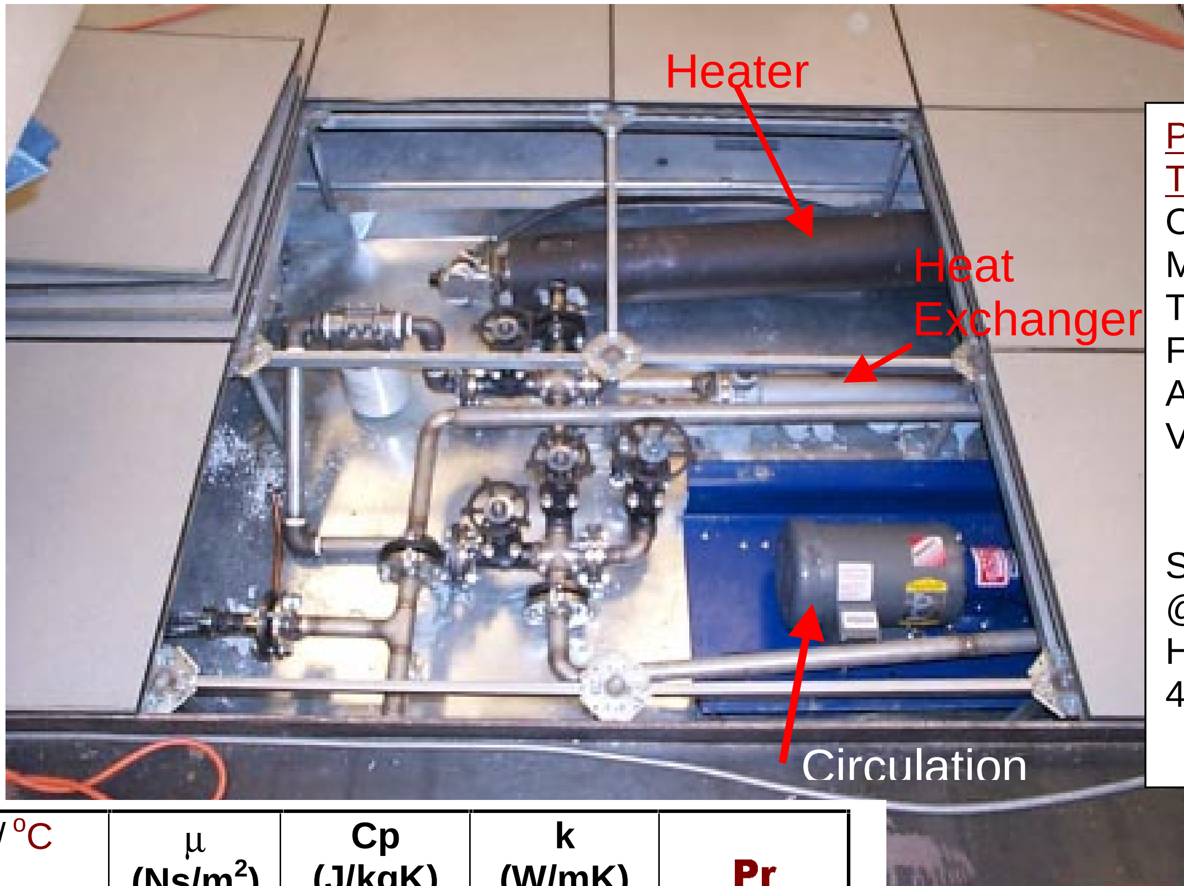
Concerns:

- Some health hazard and corrosive characteristics, but good materials and safety procedures have already been identified.
- High vapor pressure at elevated temperatures

HiTeC Paratherm NF Thermal-hydraulics Loop

Main Purpose: as a coolant for high temperature solid breeder material system thermomechanics experiments

Alternative use: as a simulant for fluid having high Prandtl numbers



<u>Paratherm NF: A Non-Fouling, Non-Toxic Heat Transfer Fluid</u>

Optimum Use Range 49 to 316 ^{o}C

Maximum Recommended Film Temperature 338 ^{o}C

Flash point 168 ^{o}C

Atmospheric Boiling Point 343 ^{o}C

Vapor Pressure psia

@	200 ^{o}F	0.0005
	300 ^{o}F	0.003

Surface Tension

@ 760 mm Hg/25 ^{o}C 28 dynes/cm

Heat transfer coefficient at 2” sched. 40 pipe @ 2.44m/s = 1891 W/m^{2}K

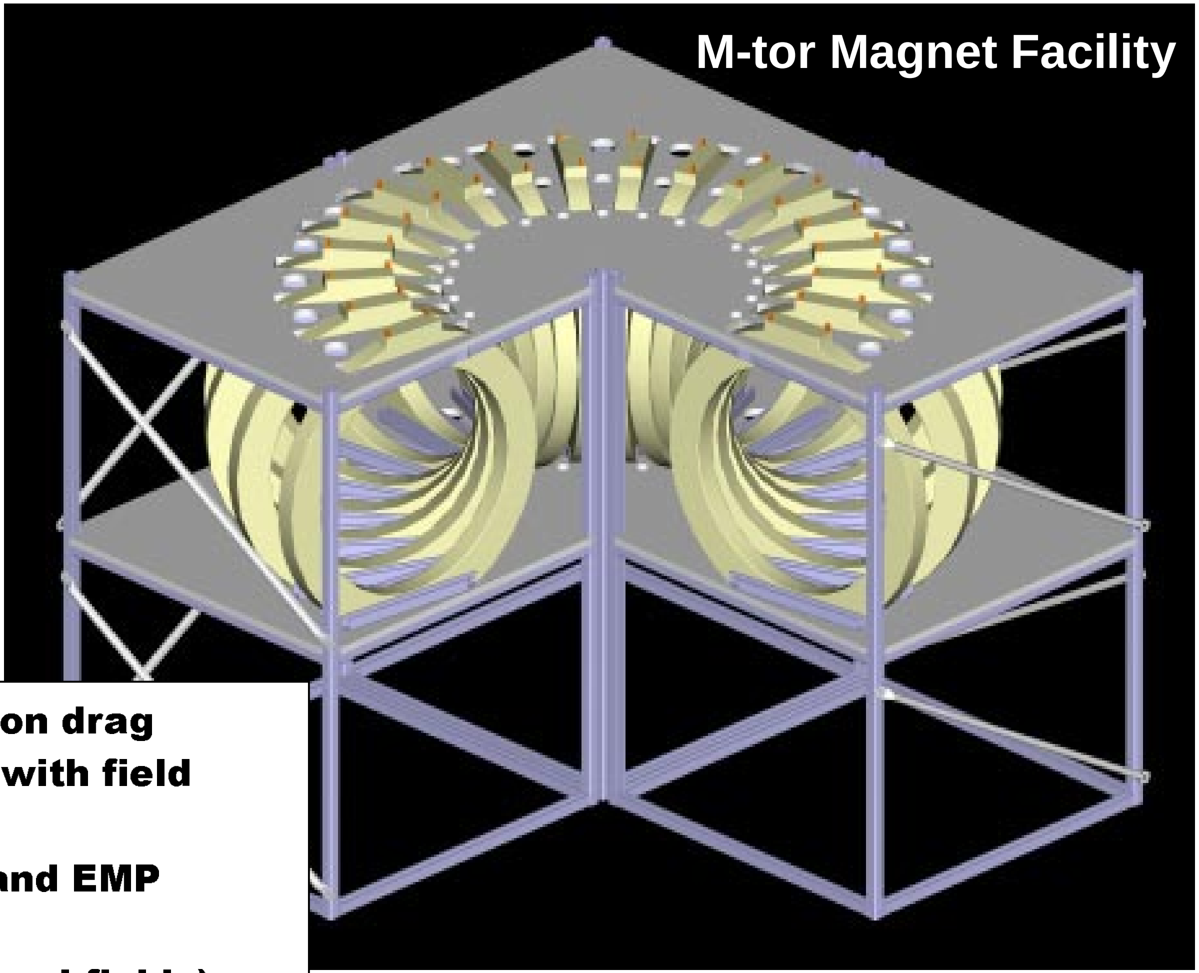
^{o}F/ ^{o}C	μ (Ns/m^{2})	Cp (J/kgK)	k (W/mK)	Pr
100/37.8	16x10^{-3}	1926	0.13156	234
200/93.3	3.5x10^{-3}	2135.4	0.128	58.39
300/148.9	1.6x10^{-3}	2344.7	0.12378	30.3
400/204.4	0.92x10^{-3}	2554	0.1194	19.68

Magnet Upgrade in MeGA-Loop

Tara coils are currently being fashioned into a torus for investigation of relevant field gradients on LM free surface flow

Status:

- ***all 24 magnets acquired***
- ***power supply acquired from PPPL***
- ***support structure under construction***



1. Field gradient effect on drag
2. Magnetic Propulsion with field gradients
3. Other forms of EMR and EMP
4. Two layer MHD flow
5. NSTX simulation (pulsed fields)

M-Tor Experimental Hardware

Development of high field magnet options

- ***Design using iron*** *gives up to 2 T field, large working volume and easily accessible test area*
- ***High current air core solenoid*** *design has potential for higher fields with existing power capabilities*

Status:

- **Design of small, low cost 4T, air core coil underway in collaboration with PPPL**