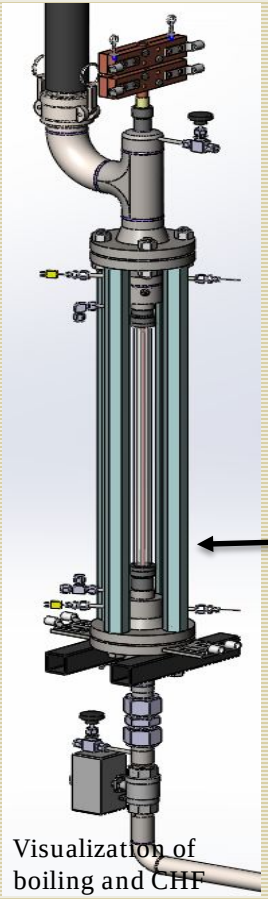
UW-Madison Thermal Hydraulics Laboratory Facilities

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

Mark Anderson

Heat transfer and CHF test facility



Visualization of boiling and CHF

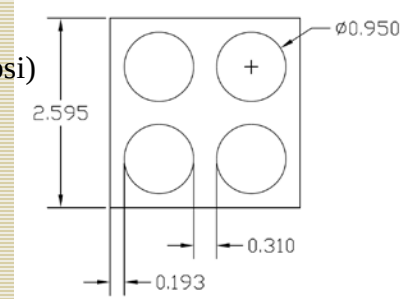
- 4 rod bundles capability at 100kW/rod
- 400 KW cooling capacity
- Option of visualization of low pressure flows
- High speed video of CHF and flow oscillations at low pressures
- Pressures from ambient to 3600psi
- Mass flux up to 3000 kg/m^{2}S
- Fluid temps to 550 C
- Pressures up to 3600 psi (25MPa)
- Can run supercritical water heat transfer conditions with a four rod simulated reactor bundle.
- Able to run cosine profile and uniform profile heat flux from simulated fuel pins
- 2 meter heated length – 3 meter overall test section height.
- Secondary side can also run low pressure transparent CHF and heat transfer up to 9 MW/m^2 heat flux

TEST CONDITIONS

Pressure: Atm – 25 Mpa (3600 psi)

Temperature: 25 – 650°C

Mass Flux: 500 – 1500 kg/m^{2}s



Sodium testing facilities (SFR's)

Operation to 650C

In house designed and constructed EM pump (current project to optimize EM pump end effects)

Full diagnostic loop to control and measure O2 concentration (cold trap, plugging meter, vanadium wire)

Used to study materials, thermal striping and thermal stratification

Facility equipped with sodium scrubber and fire protection

Up to 300 gallons of sodium flow loop testing capability

- 1 inch diameter flow loop
- 10 m/s flow in test section – 14 GPM at 15 psi head
- Able to run 12 flat samples and 10 stressed C-samples
- O_2 control (cold trap) with a plugging O_2 sensor (20ppm)
- EM - flow meter calibrated against high temp vortex
- 650 C operation temp ~ 1 gallon total Na inventory

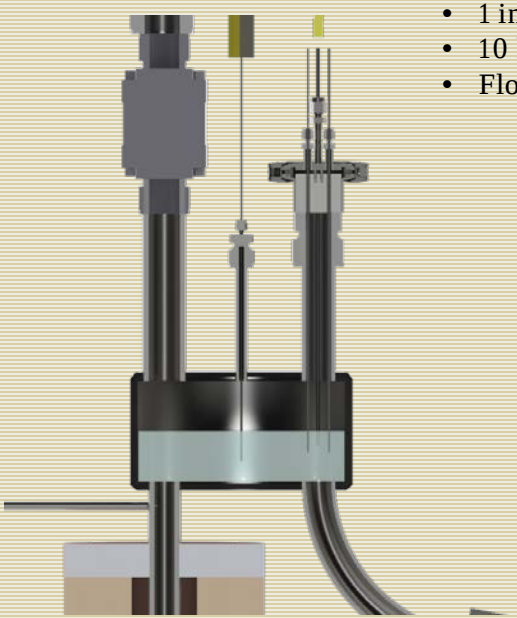
Air and water RCCS facilities (HTR)

Two concrete experimental silos with a 24 foot diameter 40 feet tall and up to 1MW electrical power

¼ scale water cooled system
30kW of heat input
2 phase flow sensors
Ability to do tank depletion tests, RCCS heat removal and fundamental multiphase flow heat transfer

¼ scale air cooled system
Housed in a 24 foot dia x 40ft tall concrete silo with control room in adjacent laboratory.
30kW heater input power
5 ton overhead crane to allow modification to the facility

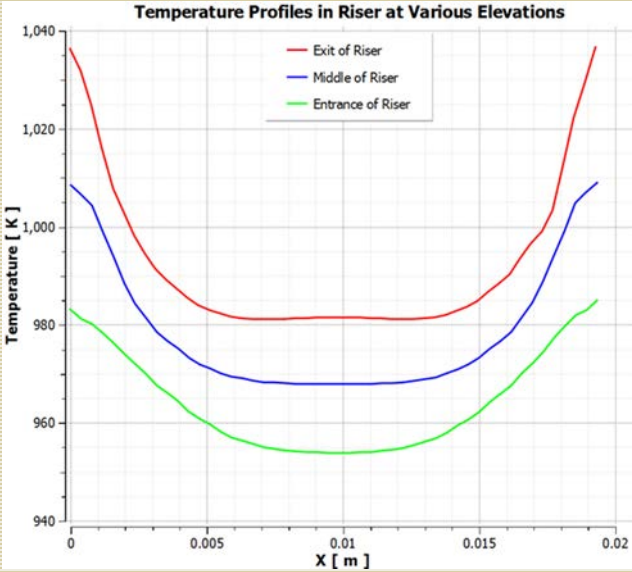
UW Flibe natural convection loop

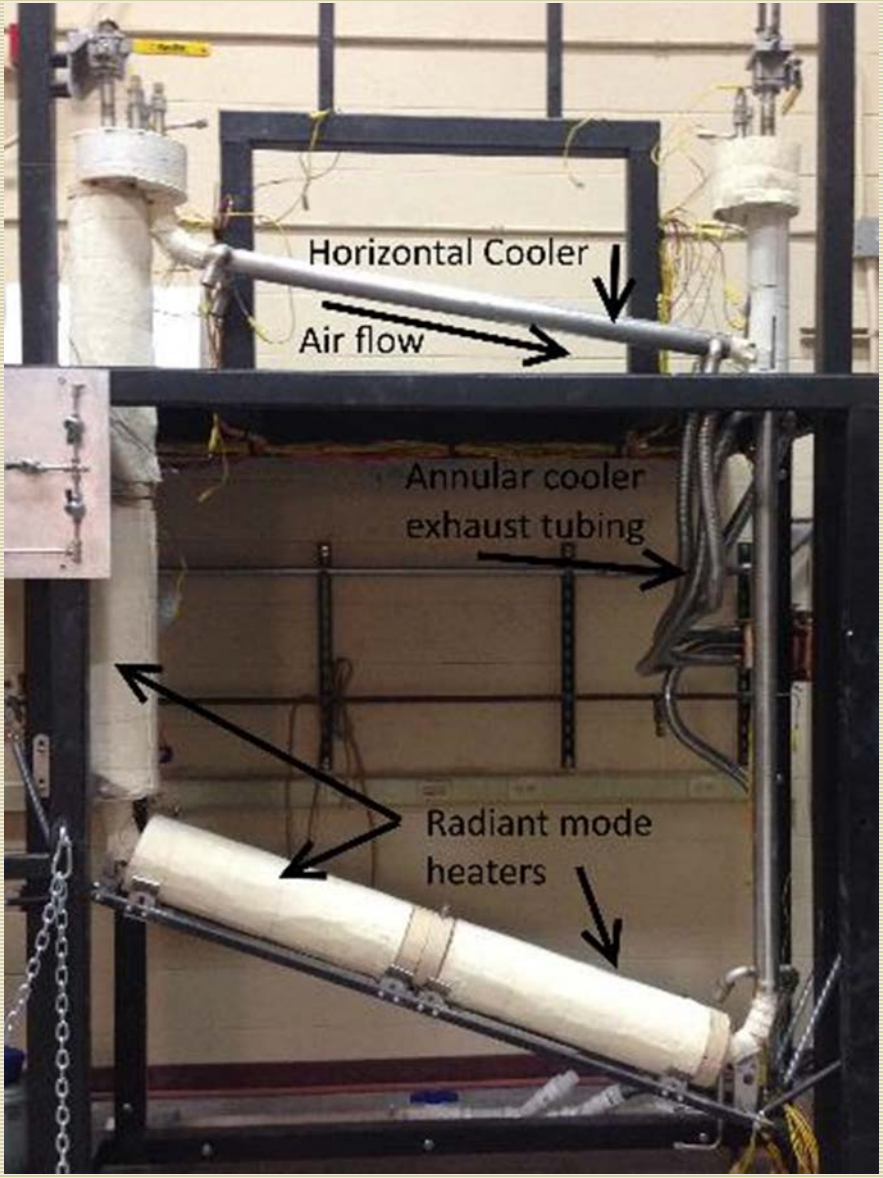


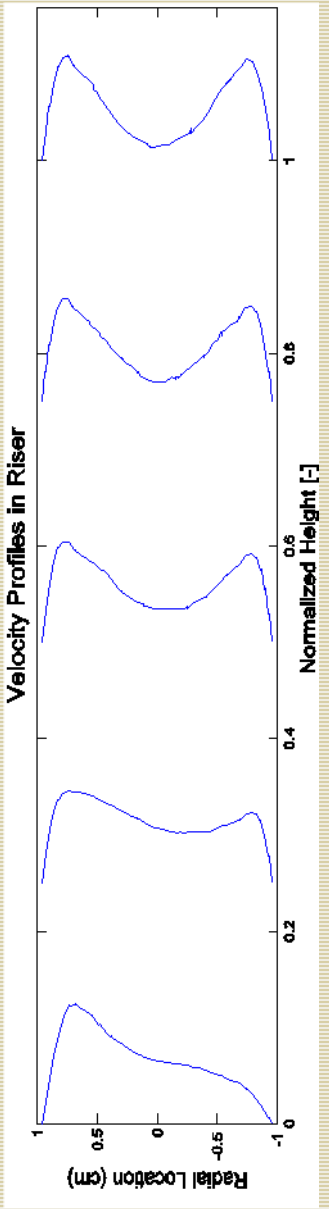
- 1 inch tube
- 10 kW of input power
- Flows on the order of 0.1 m/s

- High spatial resolution distributed fiber temperature measurements
- Online redox measurement
- Corrosion and TH testing

Glassy carbon –counter
Moly – Working/quasi-reference







On going work:

LWR – bundle test loop

- CHF tests from 18-22 Mpa
- Bundle heat transfer tests in SCWR 25MPa
- Bundle heat transfer with sCO2
- CHF of accident tolerant fuel.

RCCS (Air and water):

- Some two-phase flow stability experiments with high fidelity diagnostics

Sodium loops:

- Thermal stripping and thermal stratification testing
- EM-pump testing with (ALIP and moving magnet)

Flibe NC loop

- Thermal hydraulic testing
- Material testing
- Redox control.

Flibe purification facility

Other salt flow loops – nitrate salt testing

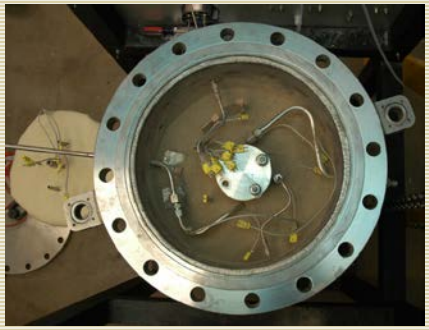
sCO2 test facilities (PCHE testing)

Nuclear reactor – instrumentation testing

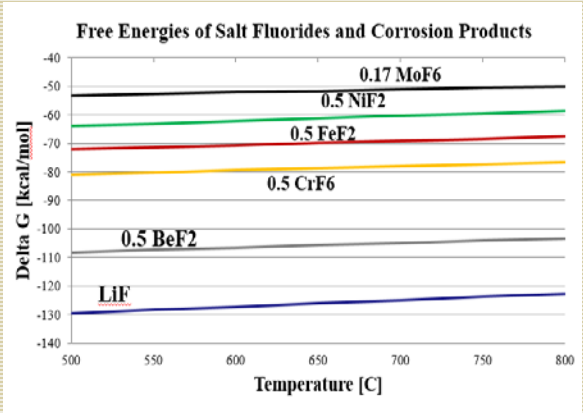
Access facility:

manderson@engr.wisc.edu

FLiBe/ fluoride/chloride Purification facility



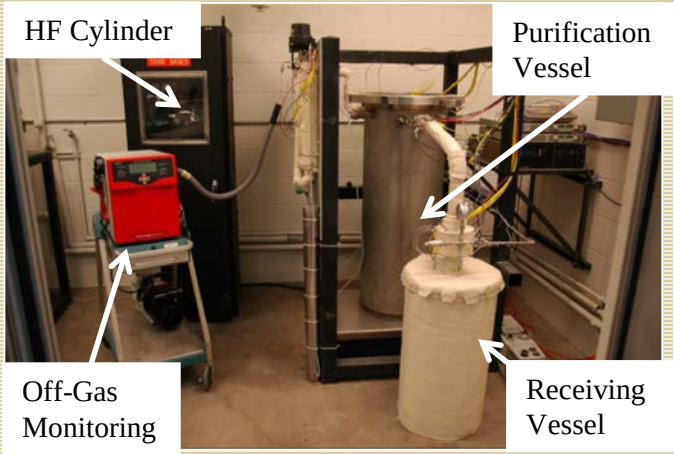
Flibe purification system

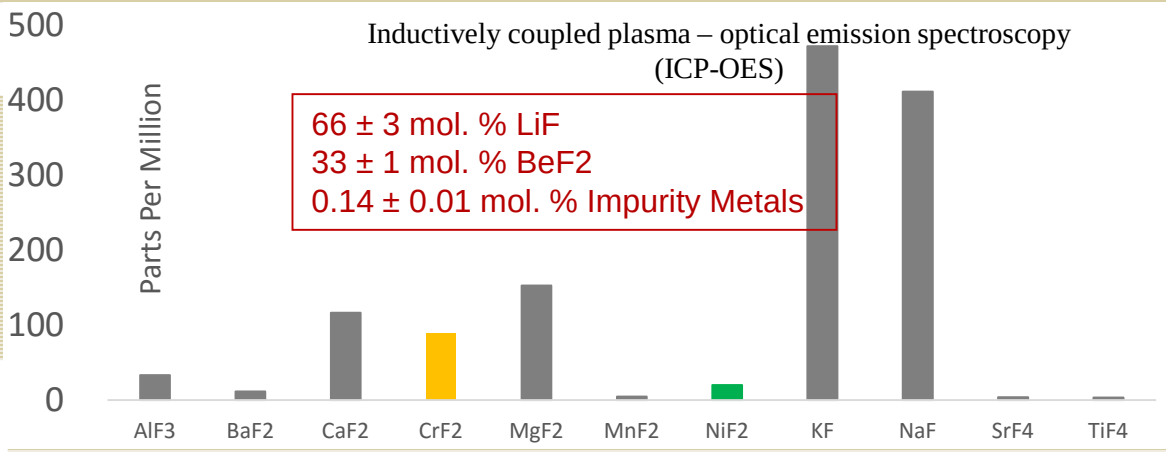


Corrosion Products
(less stable)

Salt Constituents
(more stable)

Impurity removal: Hydrofluorination purification





Purified FLiBe salt composition

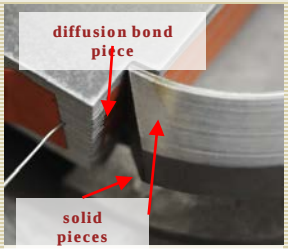
Wisconsin fluoride-salt purification

- Capable of HF/H2 purification with Be reduction of up to 70kg of salt at a time
- Salt chemical and redox analysis

B. C. Kelleher, "Purification and Chemical Control of Molten Li2BeF 4 for a Fluoride Salt Cooled Reactor," Ph.D., The University of Wisconsin - Madison, United States -- Wisconsin, 2015.

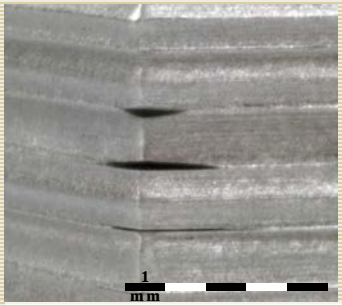
sCO2 HX and Regenerator test facility

- Up to 550 C and 3000 psi
- Flows up to
- Measure effectiveness, thermal stress, components

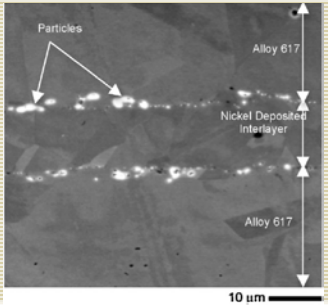


Before welding

Header welds

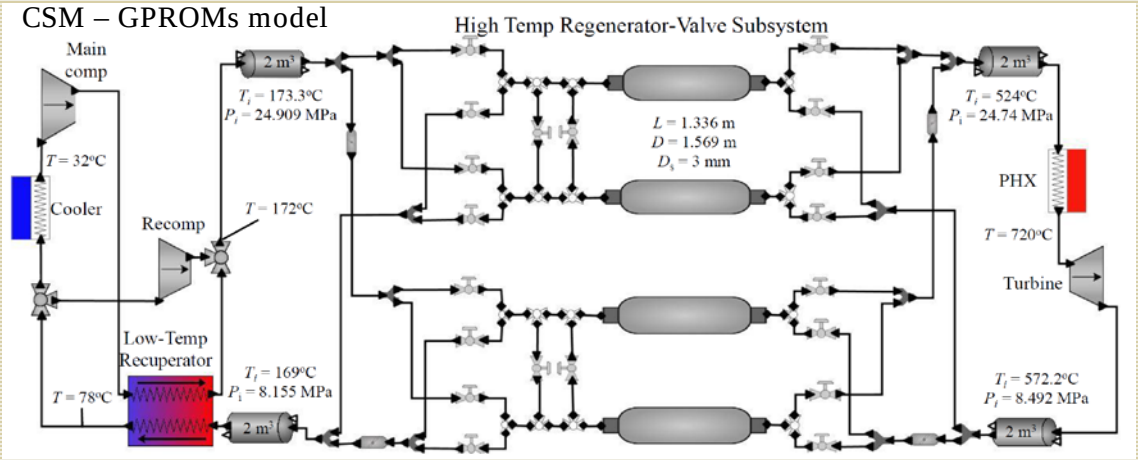


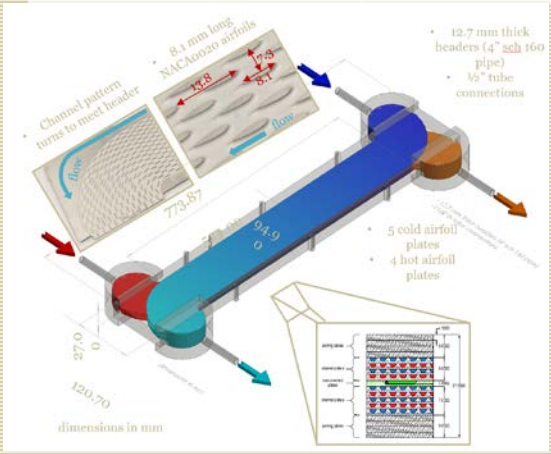
Etch-mask penetration defects



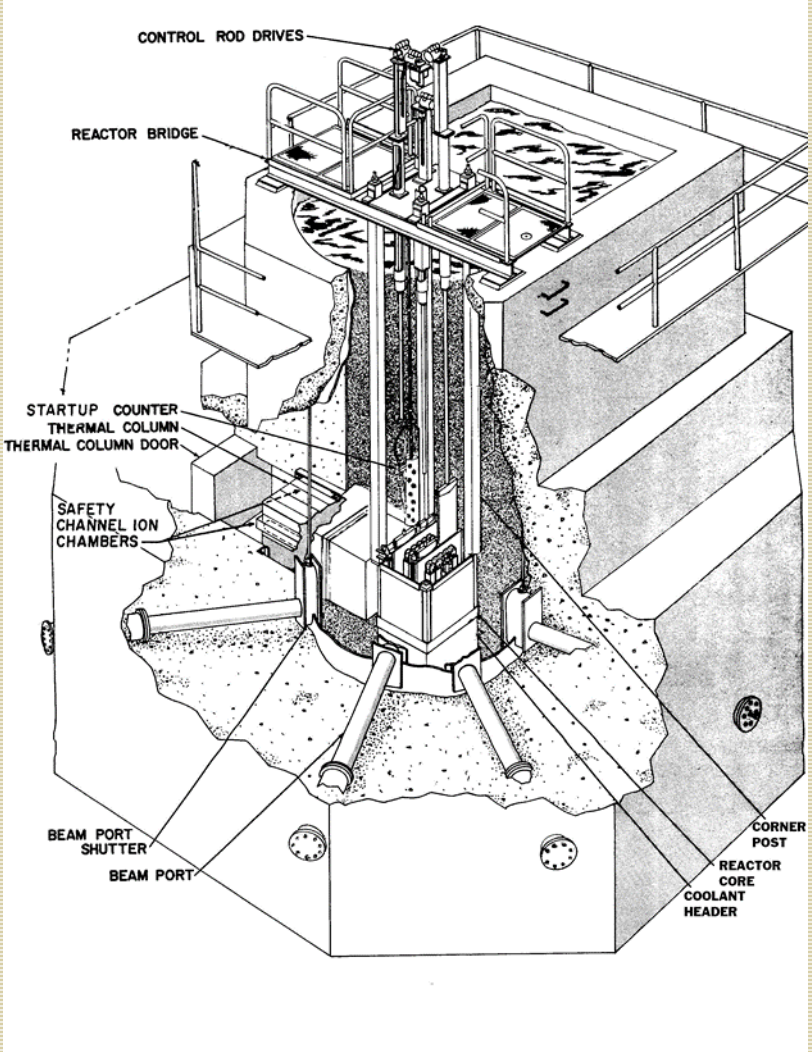
Bond inclusions in alloy 617 [1]

CSM – GPROMs model





In Core reactor instrumentation testing



Underwater housing for testing instrumentation

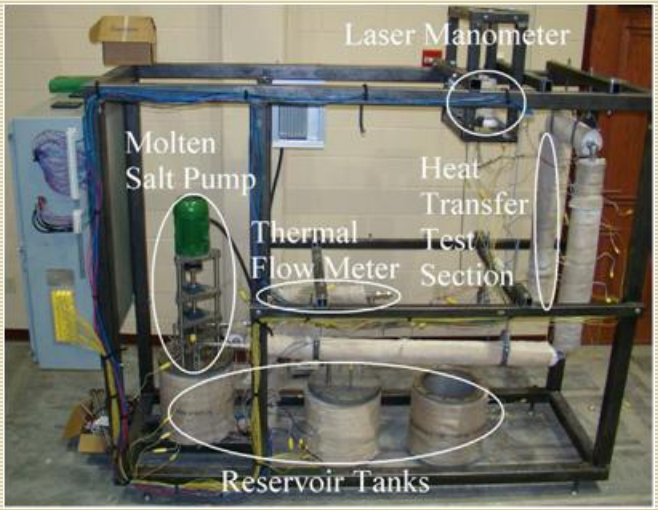
- Temperatures to 1200 C
- Neutron flux to 10^{13} n/cm^2
- Multiple ports for testing up to ½ probes
- Fast ramp and cool down rates.

High temperature Liquid salts (flow loops for thermal hydraulics, property measurements, materials testing, chemical reactivity, system design)

- Flow loop 120GPM of salt flow
- 2” diameter piping (316 ss)
- 1000 kg of salt
- Temperatures up to 650 C
- 2 GE wetted ultrasonic flow meters
- Heat exchanger and component testing
- Salt reactivity measurement capability

Large scale liquid salt flow loops

B. FLiNaK



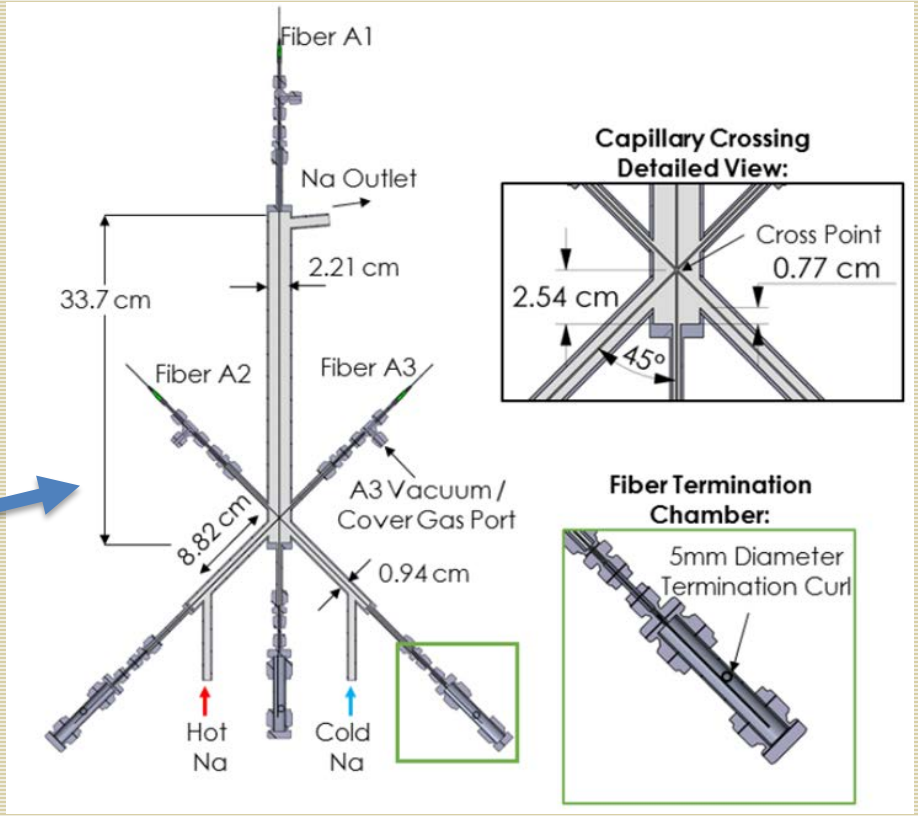
Static and flow loop materials testing

Study of reaction of salts with water and hydrocarbons

Salt (mol %)	T_m (°C)	ρ (g/cm^3)	ρ*Cp, (cal/cm*°C)	μ (cP)	*k (W/m-K)*
FLiBe	460	1.94	1.12	5.6	1
FLiNaK	454	2.02	0.91	2.9	0.92
KCl-$MgCl_2$	426	1.66	0.46	1.4	0.4
Water (H_2O) @ 20°C	0	1	0.44	1	0.6
He (P=7.5MPa)		0.0038	0.005	0.042	0.29
Na	97.8	0.78	0.23	0.18	60

*Funding: DOE NEUP, Private industry

Thermal Striping ability to use distributed optical fibers



- Test section promotes thermal striping with two jets of sodium at different temperatures impinging upon one another at a 90 degree angle.
- 3 optical fibers installed concentric to each tube of the junction as seen in figure. 5mm spatial temperature resolution