OSU Thermal Hydraulic Loops

Xiaodong Sun

Nuclear Engineering Program
Department of Mechanical and Aerospace Engineering
The Ohio State University

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- Collaborators:
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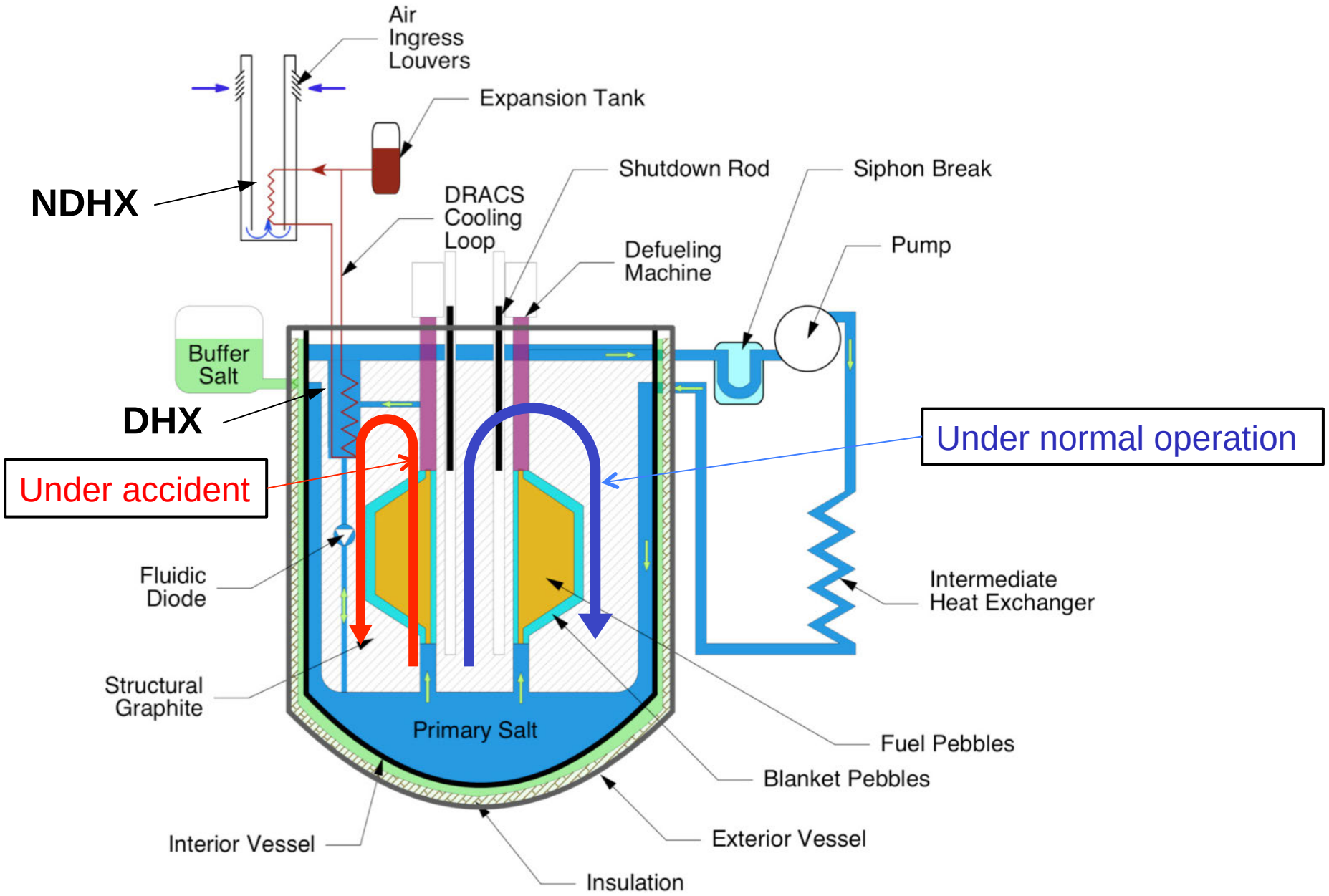
Outline

- Status of Thermal Hydraulic Loops for DRACS Testing
  - Low-temperature DRACS test facility (LTDF)
  - High-temperature DRACS test facility (HTDF)

- Additional Test Loops/Facilities
  - Component testing
  - Heat exchanger testing
  - Corrosion screening testing: SS 316H in FLiNaK
  - Reduced-scale tritium removal testing

Direct Reactor Auxiliary Cooling System (DRACS)

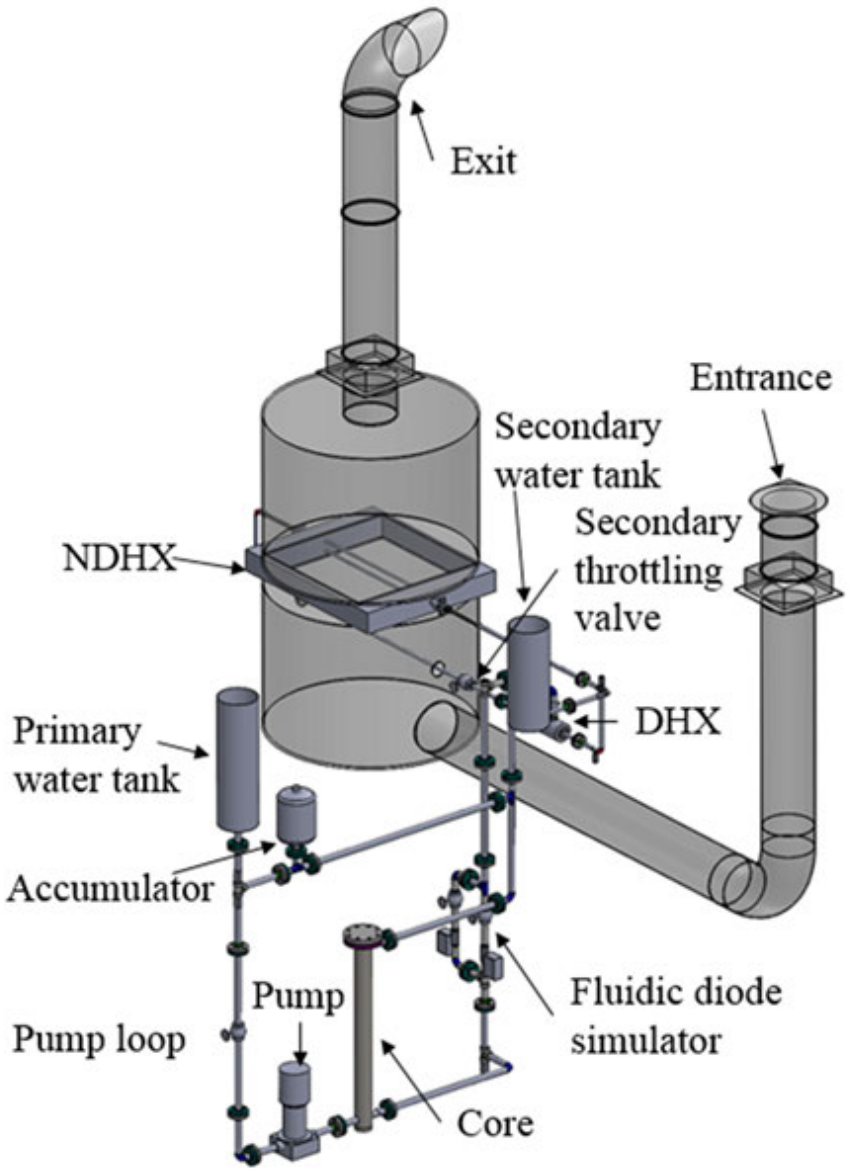


Holcomb et al. (2009)

Low-Temperature DRACS Test Facility (LTDF)

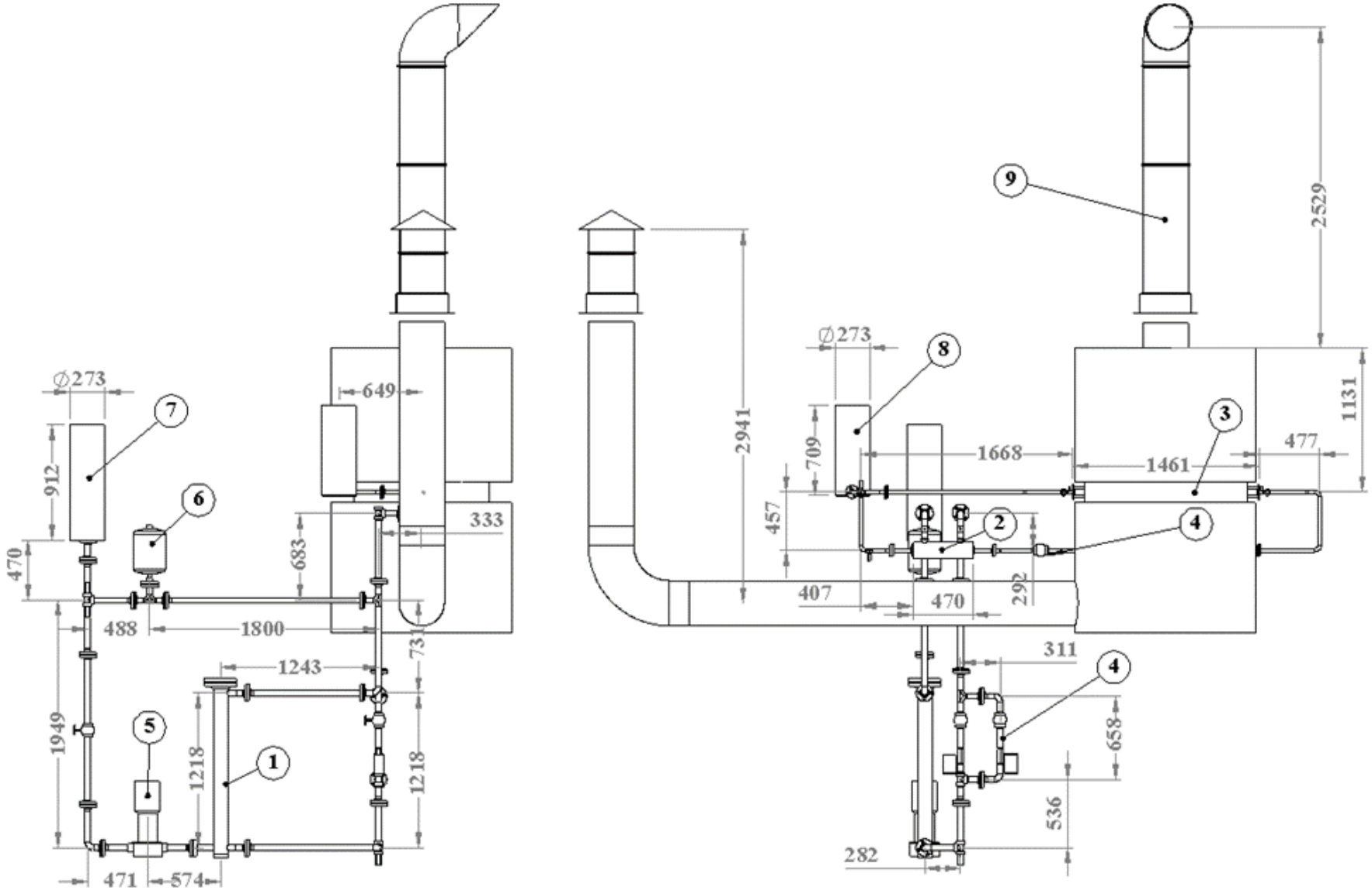
- To understand coupling and interactions of three natural circulation/convection loops
- To provide experience for construction and operation of a high-temperature salt test facility
- Construction and testing: Completed
  - DRACS startup test
  - Pump trip tests without/with IHX

	Primary water (1.0 MPa)	Secondary water (0.1 MPa)	Air
T_{hot} (°C)	76.5	65.2	40
T_{cold} (°C)	63.7	34.8	20
$\dot{m}$ (kg/s)	0.038	0.016	0.102
Loop Height (m)	1.71	0.42	3.43



LTDF (Cont'd)

LTDF: Two-Dimensional As-built Drawing



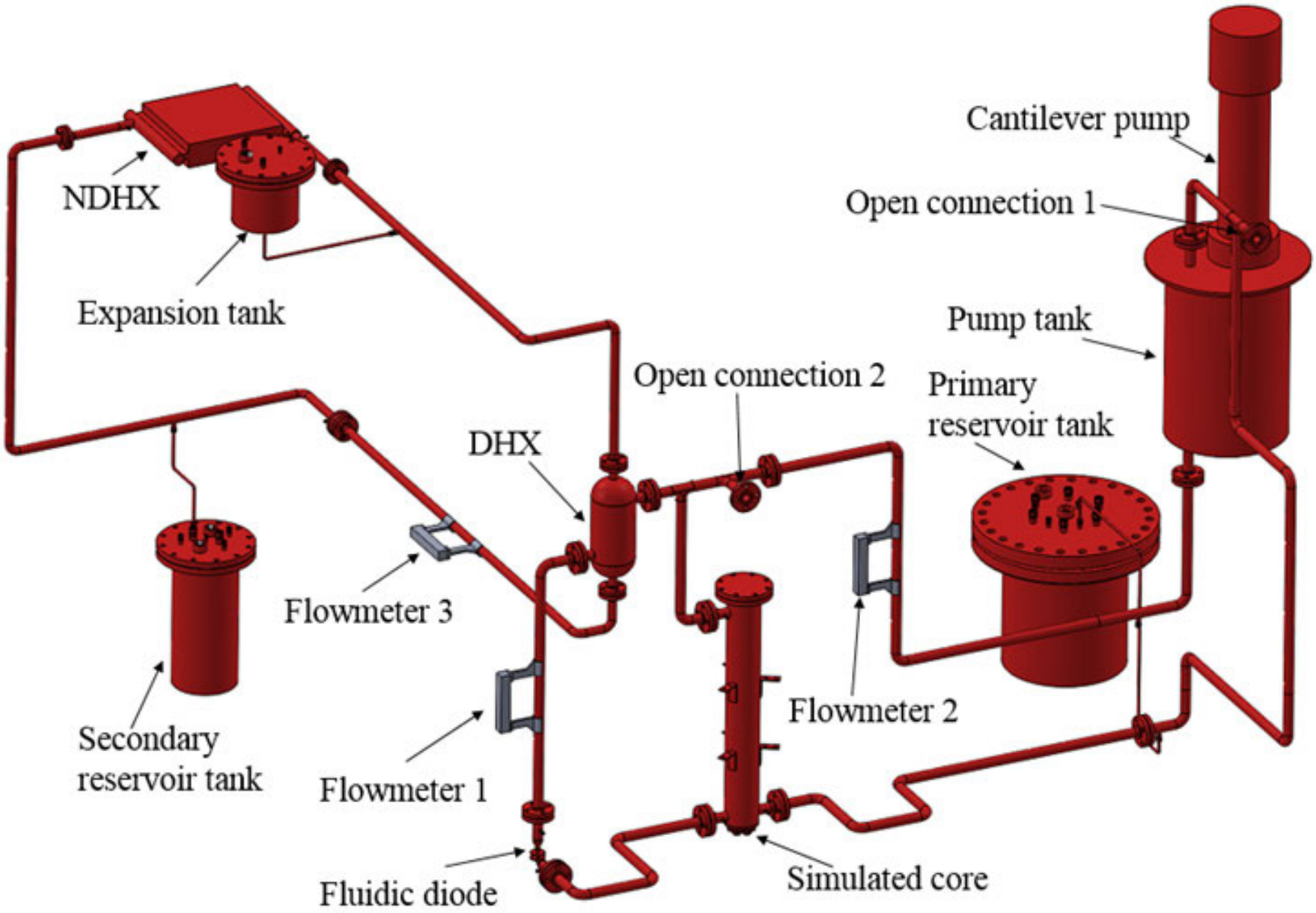
1	2	3	4	5	6	7	8	9
Core	DHX	NDHX	Secondary throttling valve	Pump	Accumulator	Primary water tank	Secondary water tank	Chimney

High-Temperature DRACS Test Facility (HTDF)

- Primary and secondary salts: FLiNaK
- Core: Simulated by seven cartridge heaters with special sheath to match fuel heat conduction time (Max.: 70 kW)
- Pump: 5-hp cantilever sump pump from Nagle
- Fluidic diode: Vortex diode
- Fully instrumented: Clamp-on ultrasonic flow meters (Flexim); N-type thermocouples (Omega); level measurement (Delta Controls); in-house solution for the differential pressure measurement
- Construction completed, salt being prepared

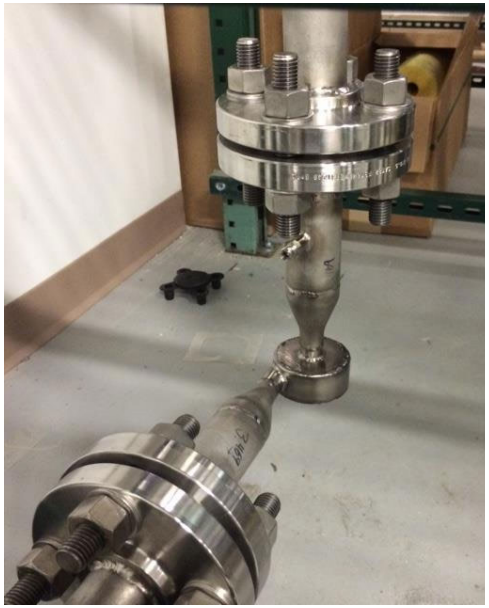
	Primary Fluid (FLiNaK)	Secondary Fluid (KF and ZrF_4)	Air
T_{hot} (°C)	722	666	110
T_{cold} (°C)	678	590	40
$\dot{m}$ (kg/s)	0.120	0.127	0.142
Loop Height (m)	1.14	1.08	3.43

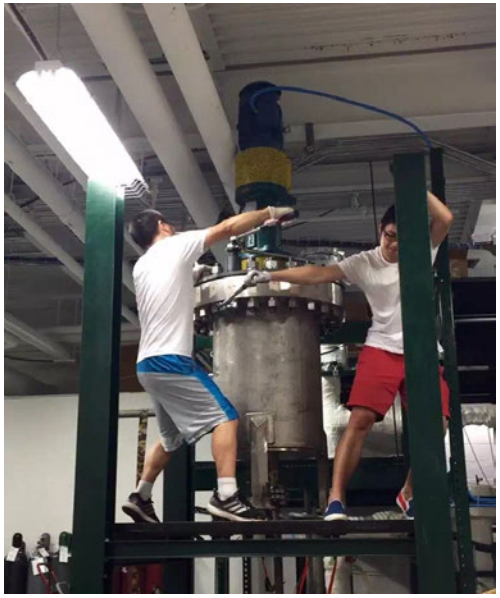
HTDF (Cont'd)


NDHX
Expansion tank
Cantilever pump
Open connection 1
Pump tank
Open connection 2
Primary
reservoir tank
DHX
Flowmeter 3
Secondary
reservoir tank
Flowmeter 1
Flowmeter 2
Fluidic diode
Simulated core

HTDF (Cont'd)

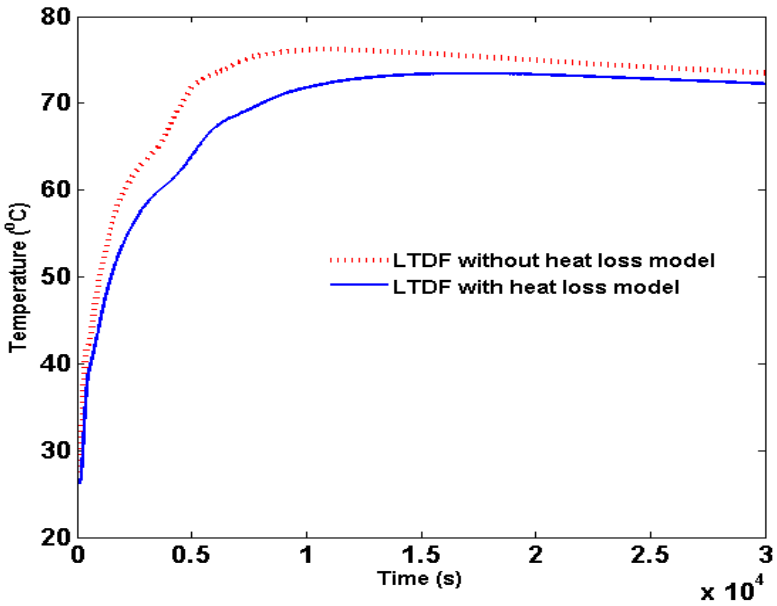




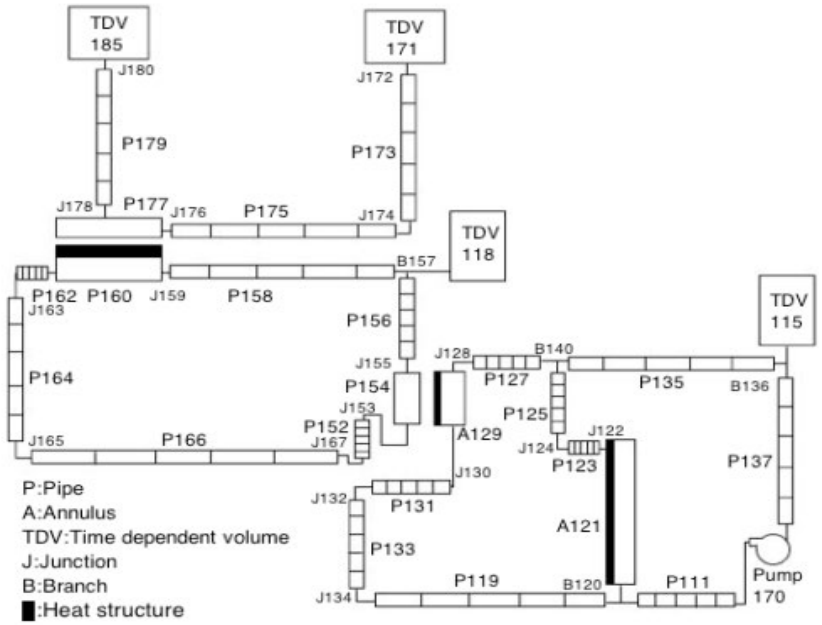



LTDF and HTDF Models in RELAP5

- RELAP5/SCDAPSIM/MOD 4.0
  - Selected for thermal hydraulic system-level code V&V
  - Salt property implementation
- RELAP5 models of LTDF and HTDF
  - Working fluid in LTDF: water, water, and air
  - Working fluid in HTDF: FLiNaK, KF-ZrF_4, and air
- Heat loss considered: Piping, flanges, and insulation



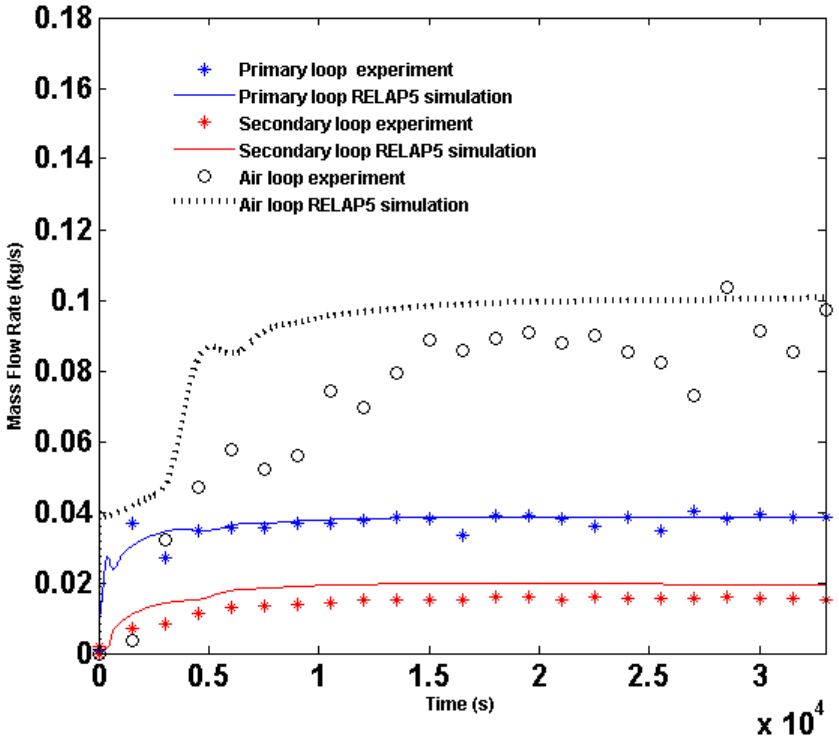
Comparison of with and without heat loss model

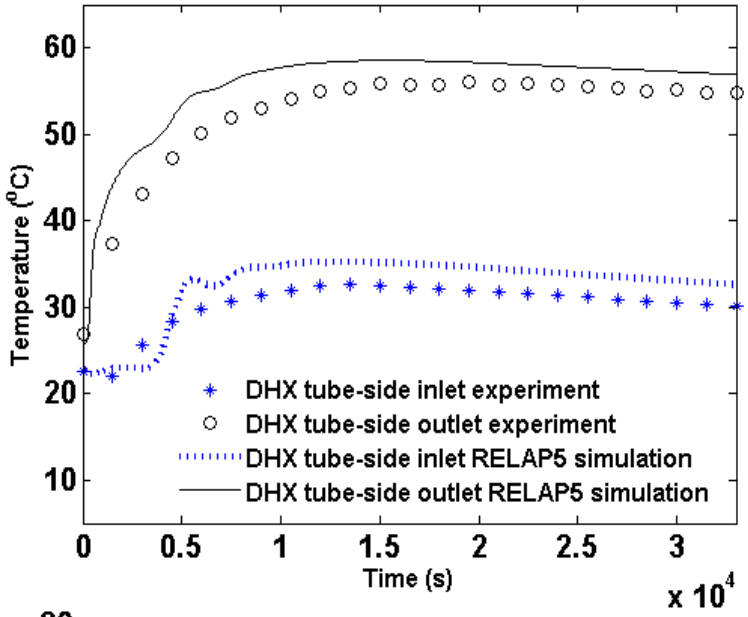


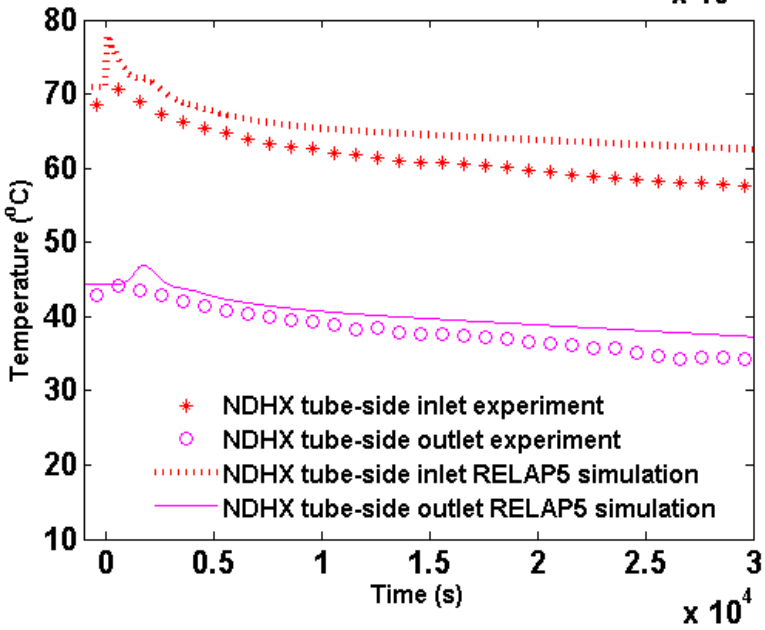
HTDF model in RELPA5

LTDF Benchmark Study

- RELAP5 simulation results against LTDF experimental data
  - DRACS startup scenario
  - Pump trip scenario

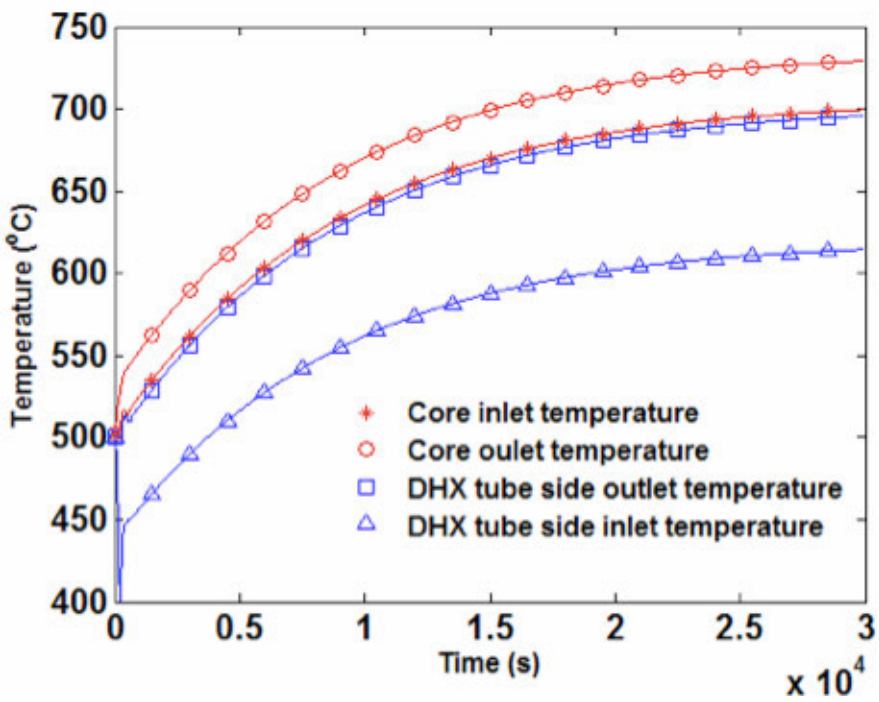


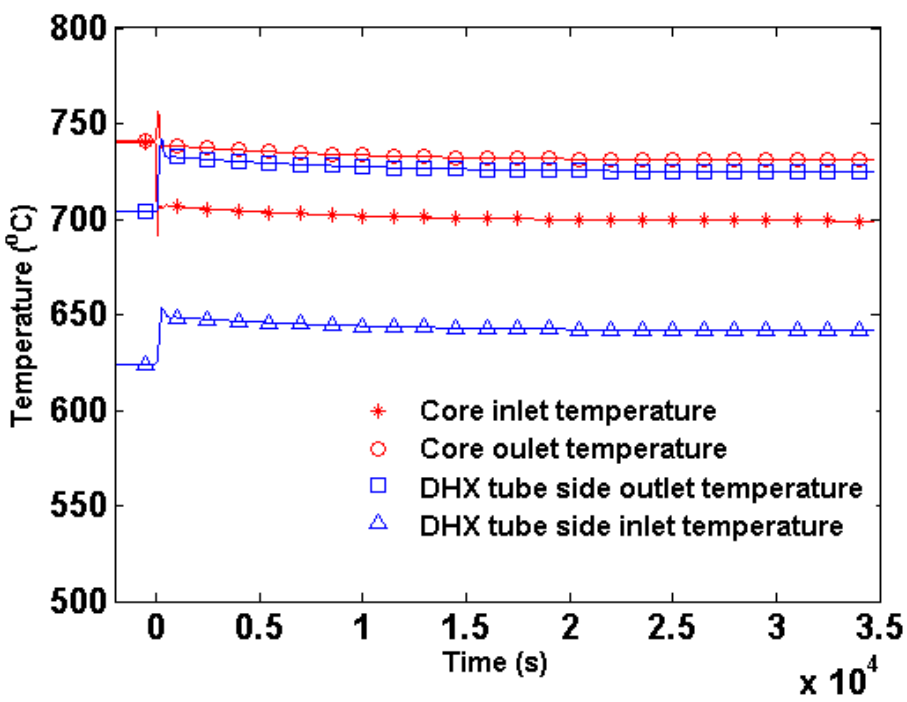




HTDF Simulation Results

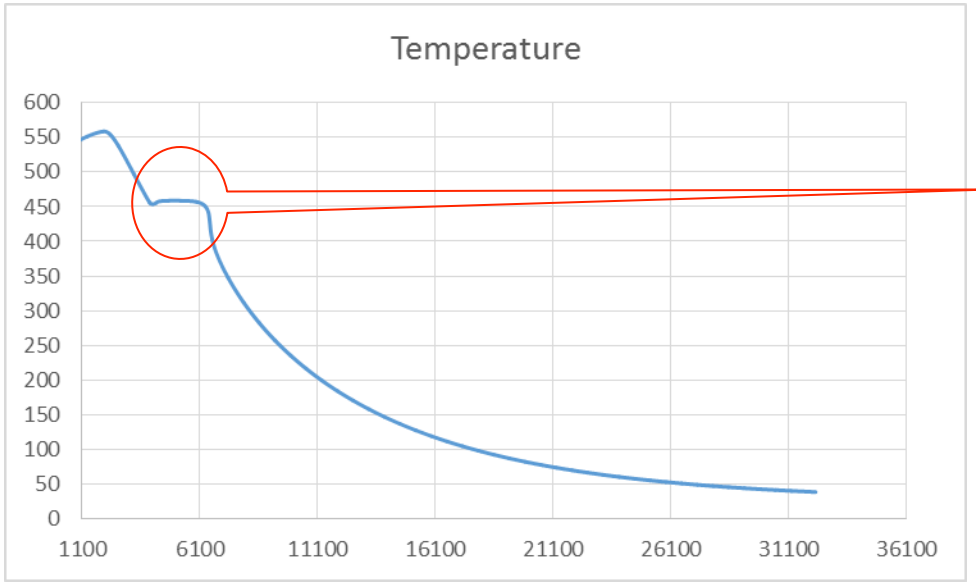
- Thermodynamic and transport properties of molten salts (FLiBe, FLiNaK, and KF-ZrF_4) have been implemented into RELAP5
- RELAP5 transient analyses
  - DRACS startup scenario
  - Pump trip scenario
- Benchmark study to be performed when experimental data become available

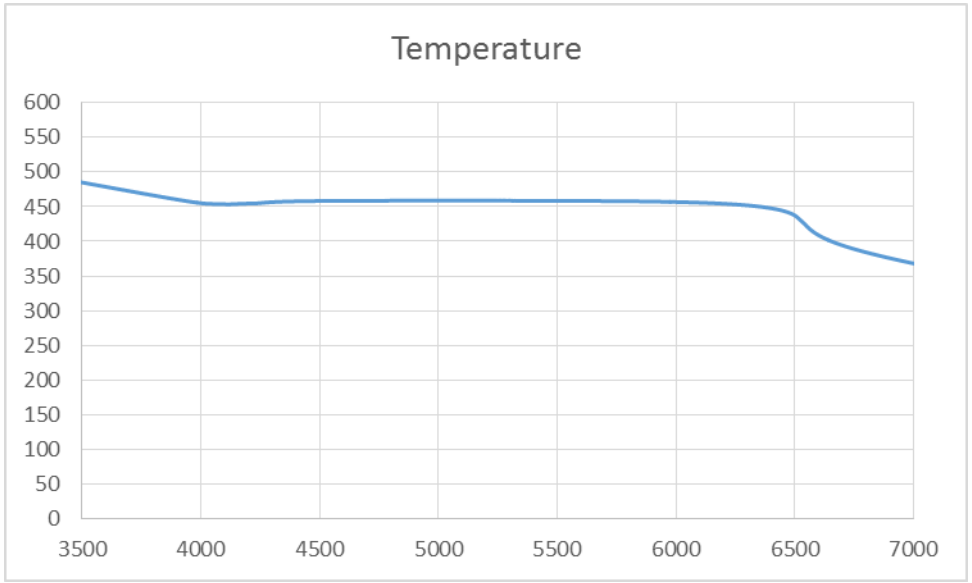




Salt Processing

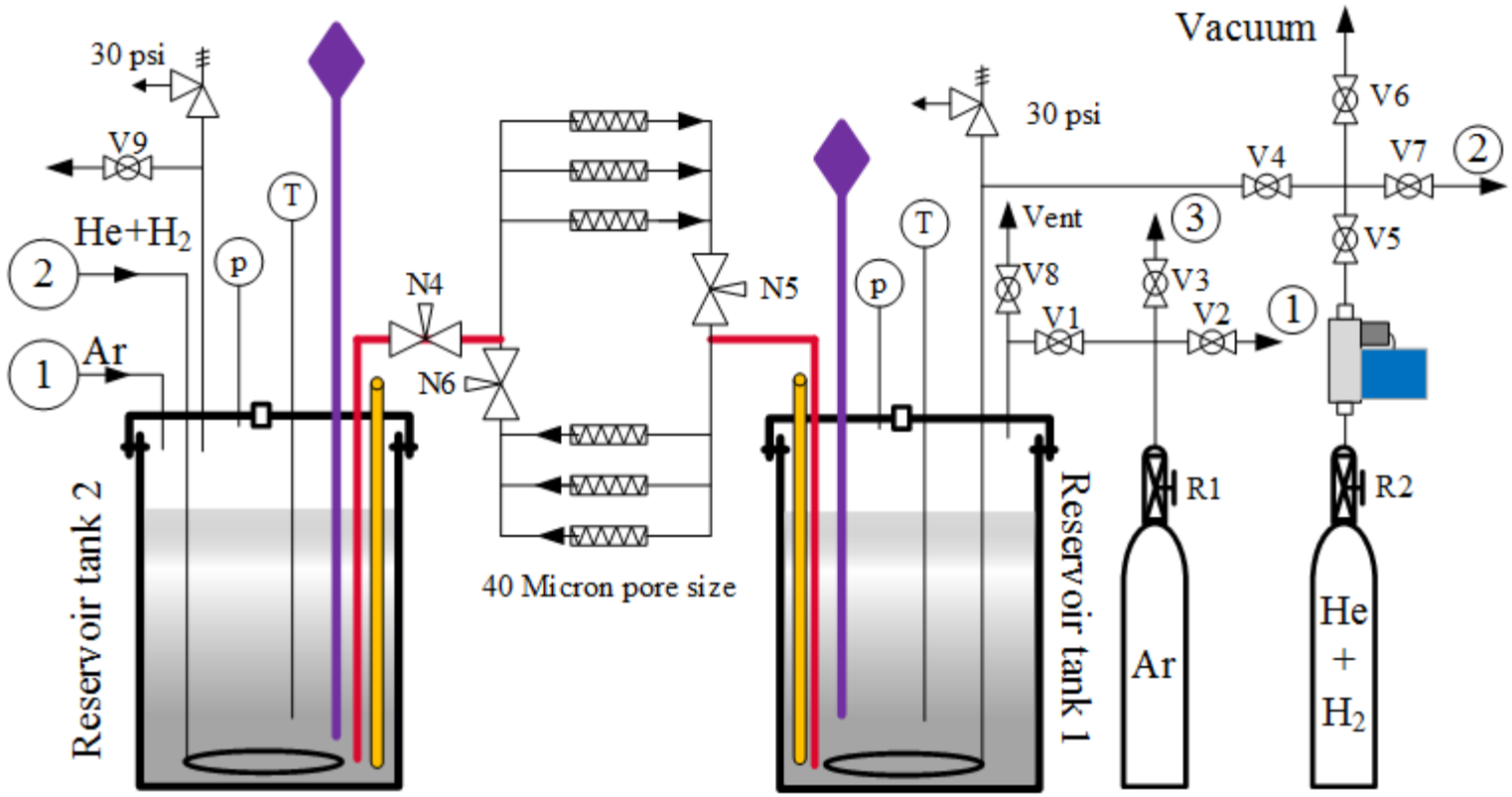
- Preparing salt mixture
  - Further dehydrate the constituent salts at a controlled temperature (~ 150 to 200 ^{o}C)
  - Weigh and mix the salts in a controlled environment (glove box)
- FLiNaK melting point measurement
  - A flat-temperature stage corresponding to salt freezing
  - Melting point of 458.7 ^{o}C (average over 4500 - 5500 s)





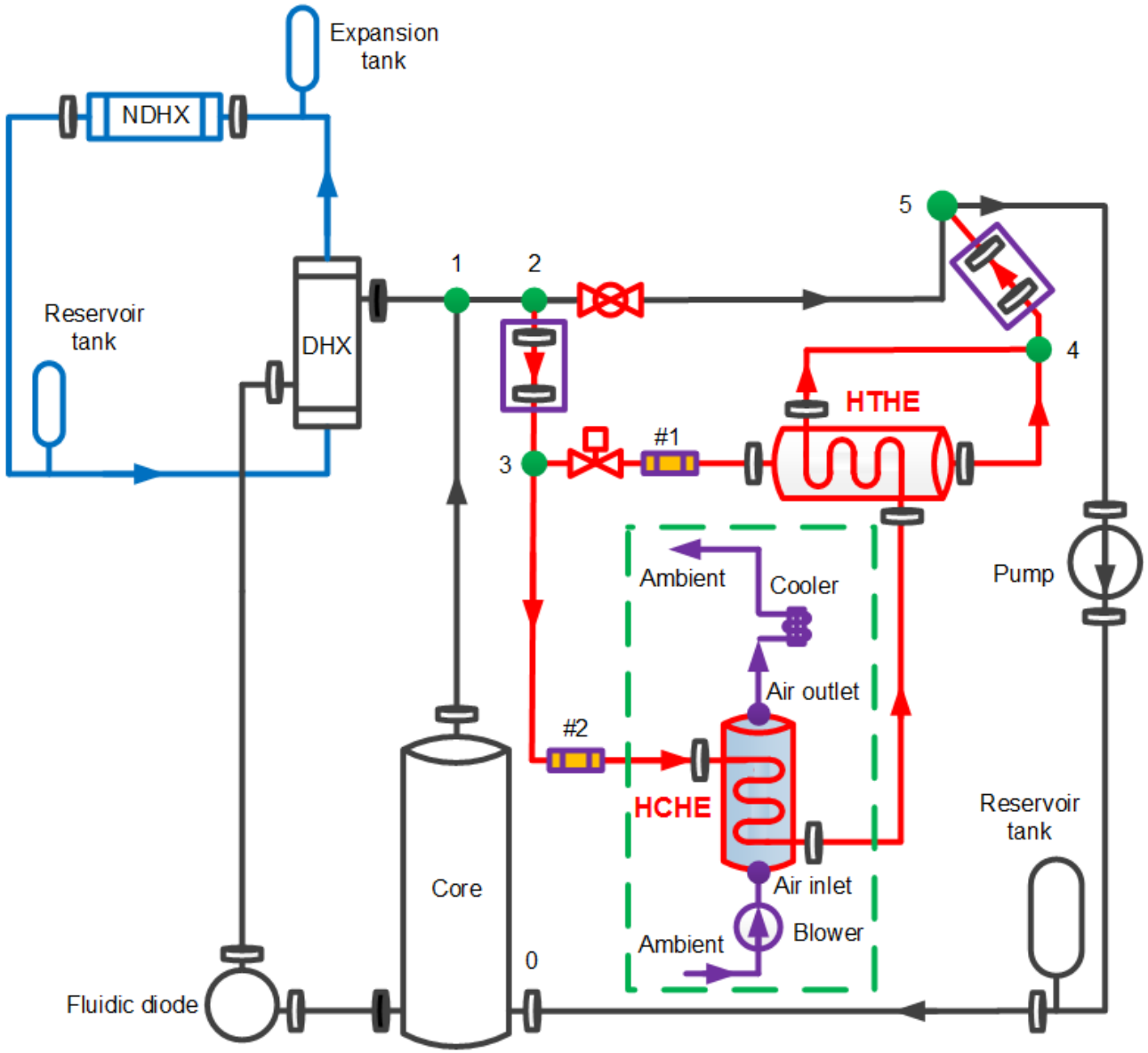
Salt Purification and Component Testing

- Filtering molten salt
- Testing valves
- Benchmarking ultrasonic flow meters under high-temperature liquid salt conditions
- Calibrating level sensors
- Testing differential pressure measurement method

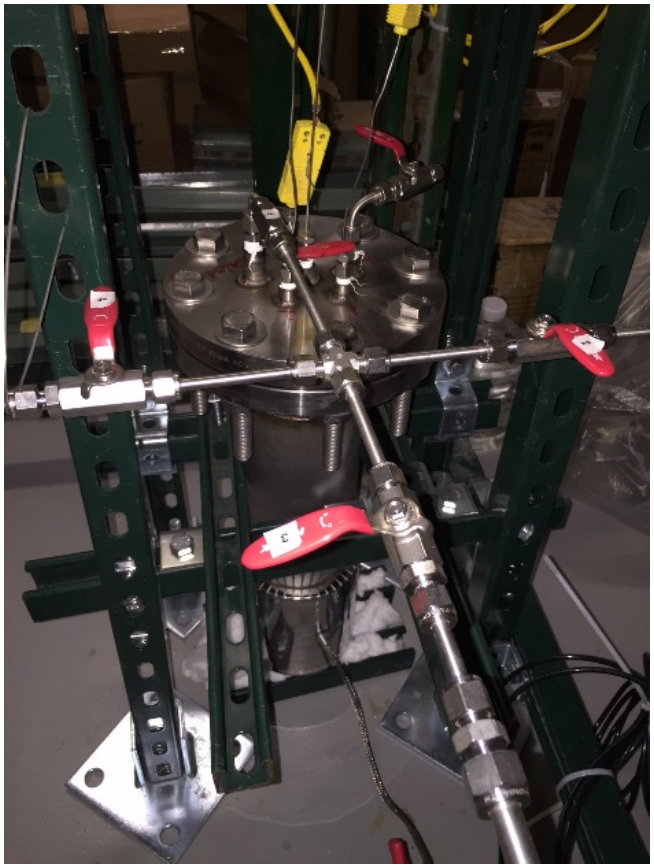


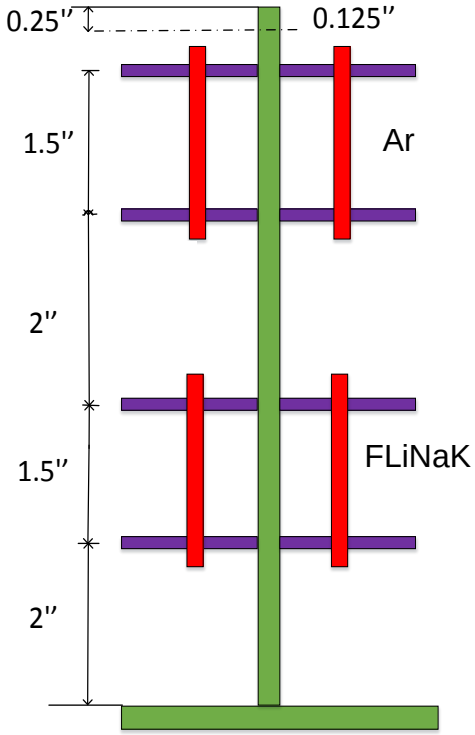
Heat Exchanger Testing

- Additional components are being added to the HTDF to facilitate HX testing under salt-salt and salt-air conditions



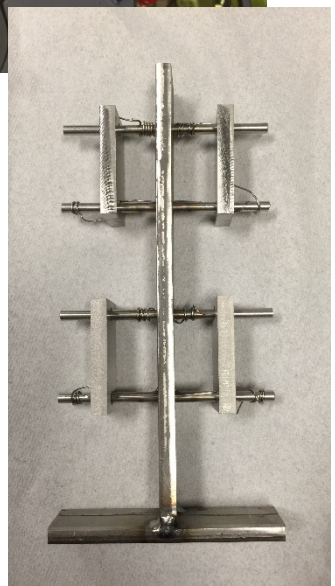
Corrosion Screening Testing

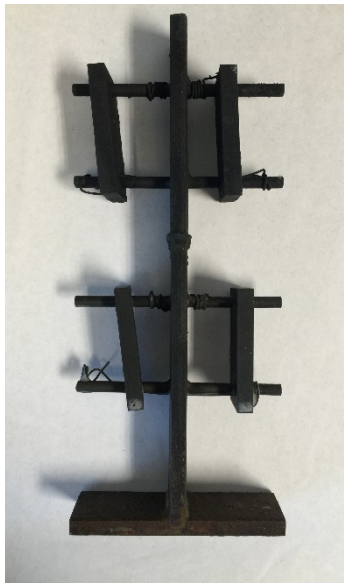




Operating Condition:

- Salt: FLiNaK
- Cover gas: Ar
- Temperature: 722 ^{o}C
- Time: 103 hrs
- Test specimen: SS 316H



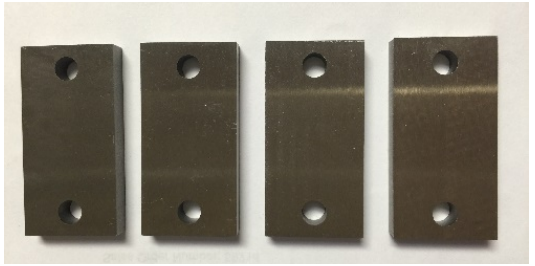


Corrosion Screening Testing (Cont'd)

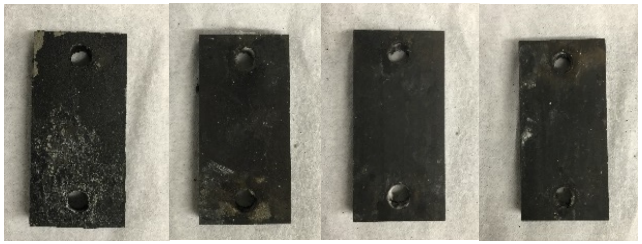
Ultrasonic cleaner

A B C D

Before testing



Before cleaning



After cleaning

Cleaning

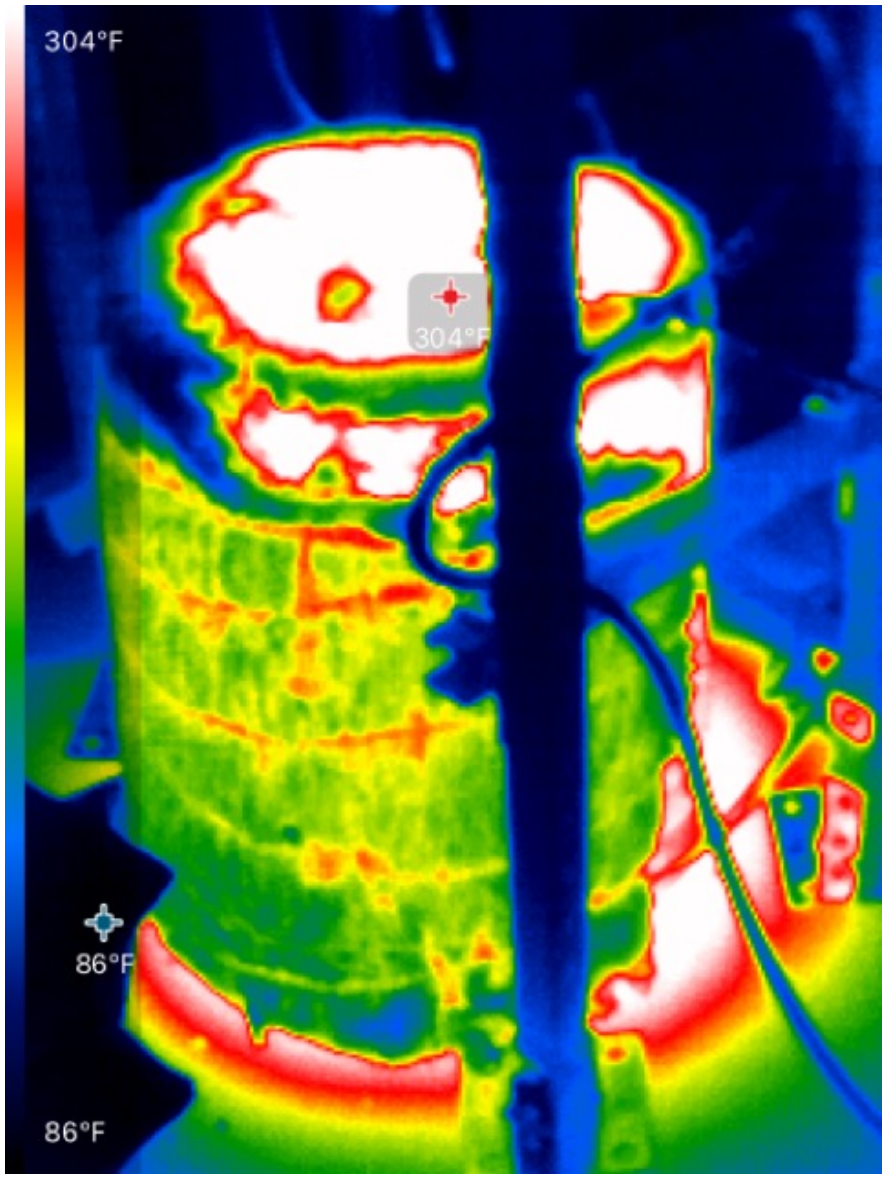
- $Al(NO_3)_3$: 1 mol/L
- Distilled water

Corrosion Rate

A: 3.12 mg/cm^2-d B: 3.07 mg/cm^2-d

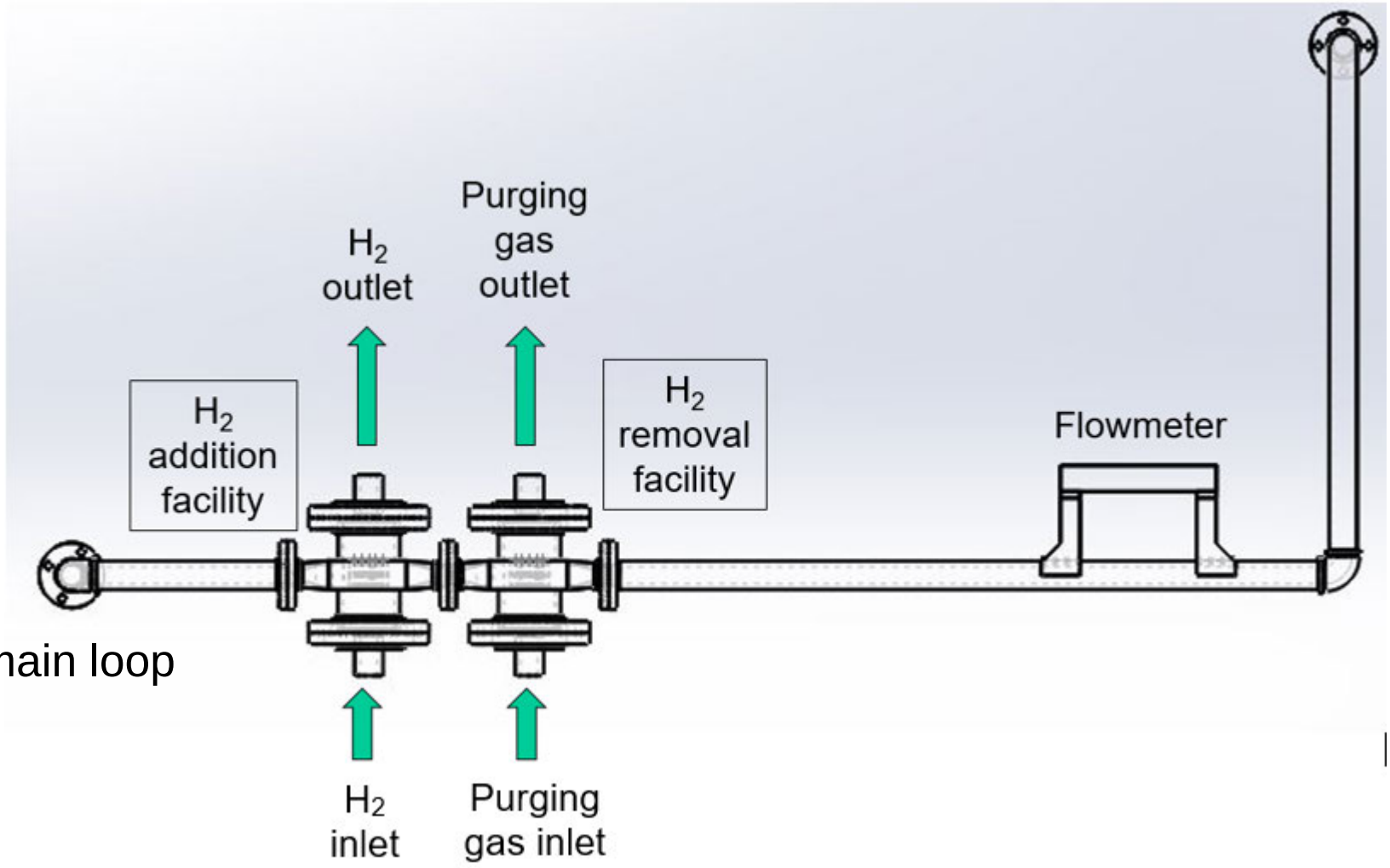
C: 2.87 mg/cm^2-d D: 2.88 mg/cm^2-d

Corrosion Screening Test (Cont'd)



Reduced-scale Tritium Removal Testing

Back to main loop

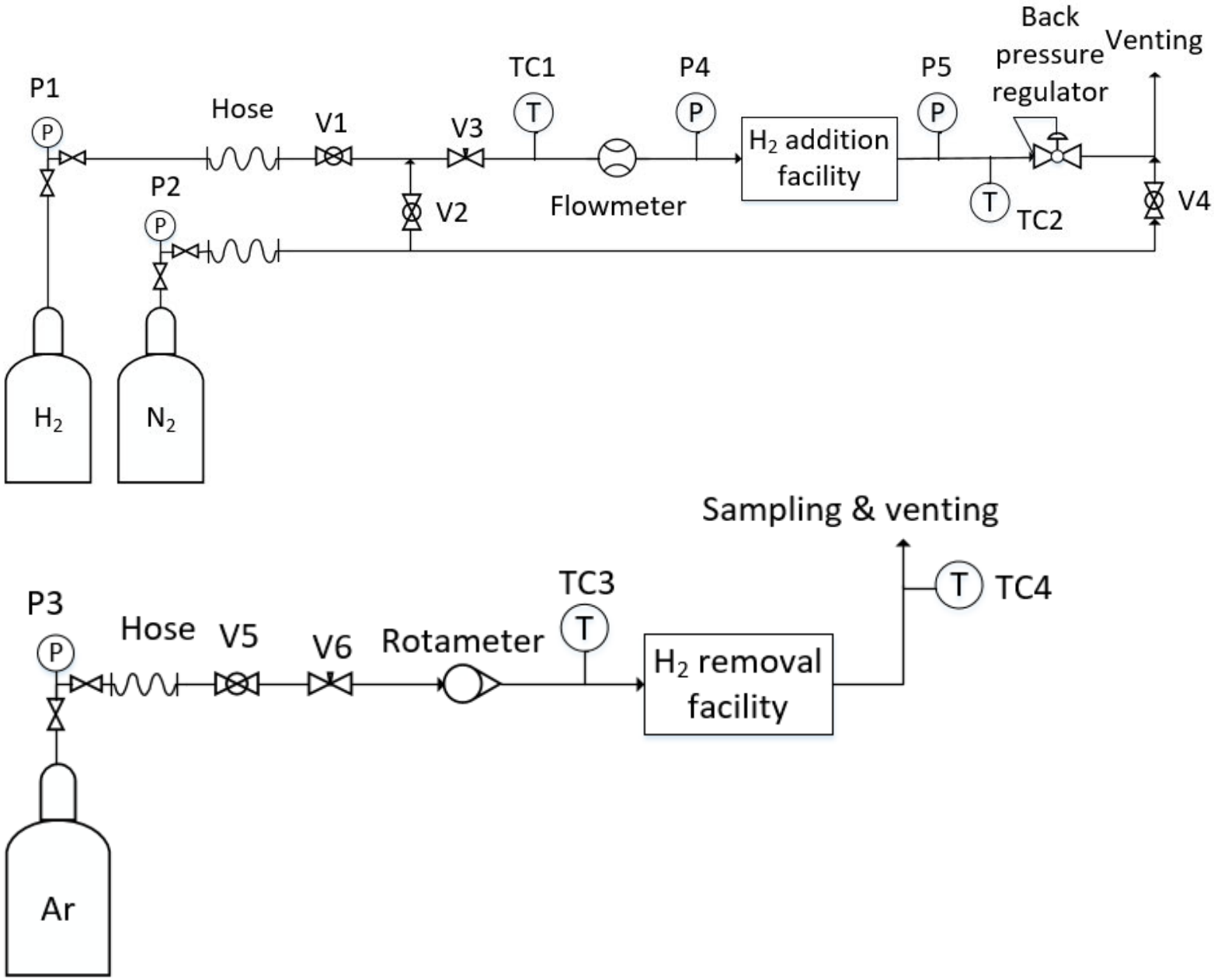


From main loop

Reduced-scale Tritium Removal Testing (Cont'd)

H_2 addition gas line

H_2 removal gas line



Reduced-Scale Tritium Removal Testing (Cont'd)