Single **P**rimary **H**eat **E**xtraction and **R**emoval **E**mulator (**SPHERE**)

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Demonstration and Support: SPHERE

- Power Transient Testing
  - Idaho National Laboratory has completed testing on power transients of a high-performance sodium filled heat pipe with a range of operating conditions. The resulting temperature profiles from this testing will be utilized to aid in the validation of the startup and shutdown portions of the heat pipe modeling code, Sockeye.
  - Outcome: Provided data to Sockeye development team for model V&V for a series of power transients and heating profiles

- Long Duration Testing
  - Idaho National Laboratory has completed testing over a long duration of a high-performance sodium filled heat pipe while monitoring axial temperature profile, power supplied by the heaters, and heat removed by a gas-gap calorimeter
  - Outcome: Provided data on heat pipe degradation over 1000 hours to Sockeye team

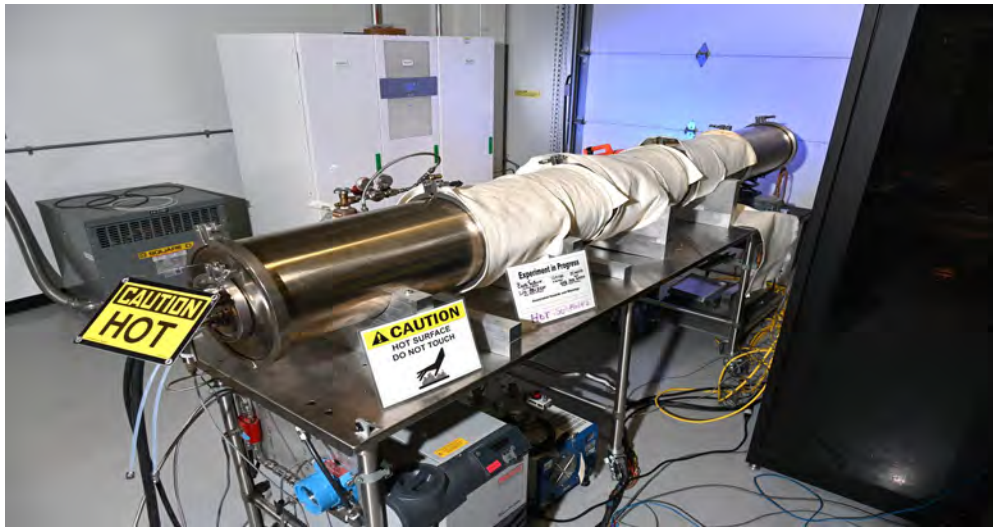

Fig. Sphere Test Bed

Fig. Instrumentation sodium filled heat pipe

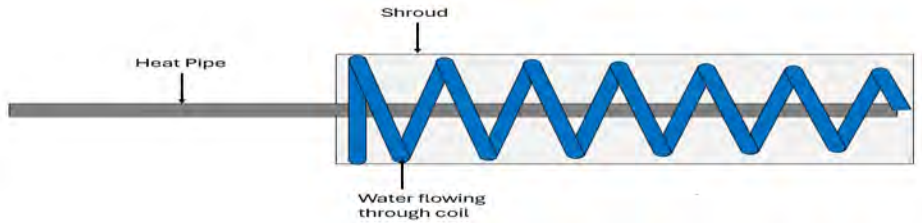

Fig. Calorimeter for heat removal

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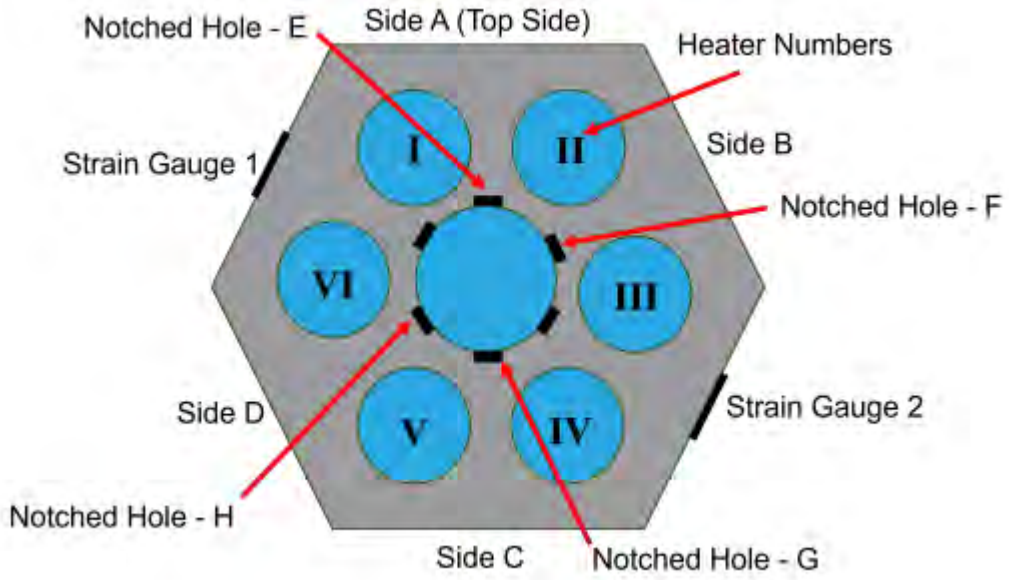
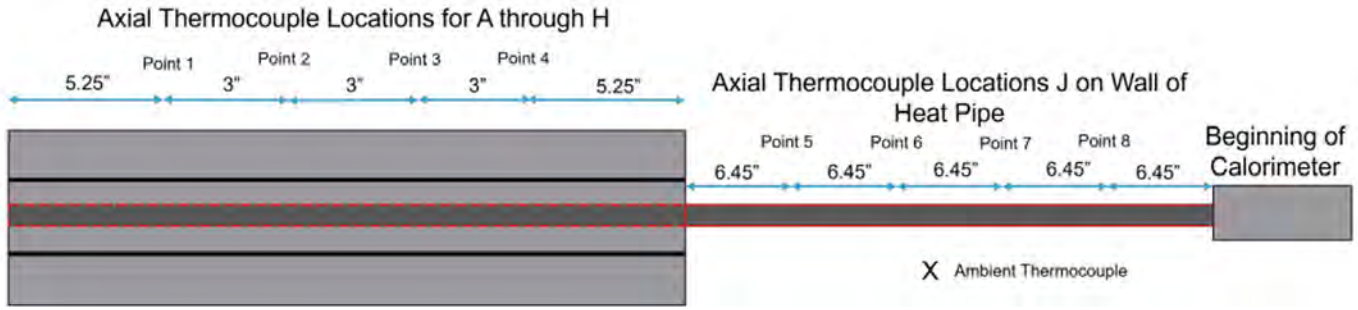
FY 24 Summary: Power Transient Testing

- Obtain experimental data from a high-performance sodium heat pipe while performing a variety of power transients
- Deliver data to SOCKEYE developers to aid with model validation

Power Transient Testing: Test Setup

- Similar to previous gap conductance testing
  - Model was already made for this setup
- Instrumentation
  - Strain gauges
  - Type K thermocouples
  - Gas gap calorimetry
  - Watt transducers





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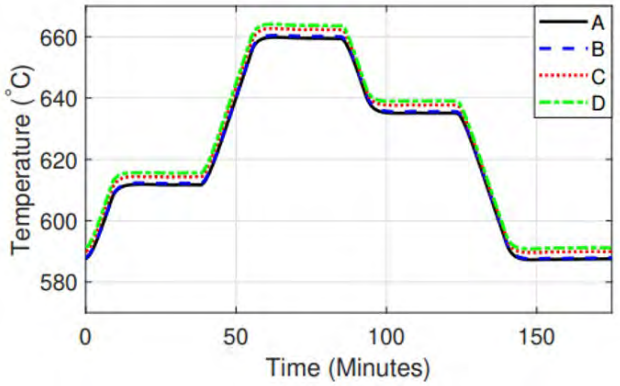
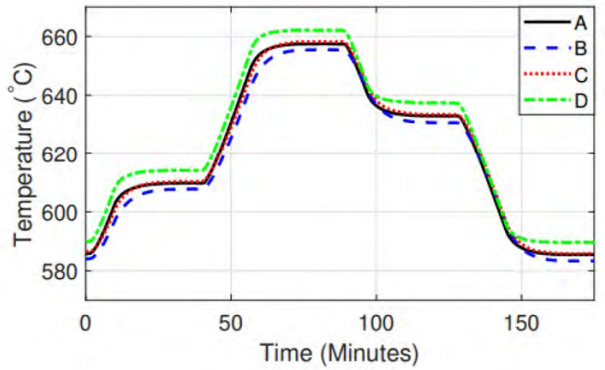
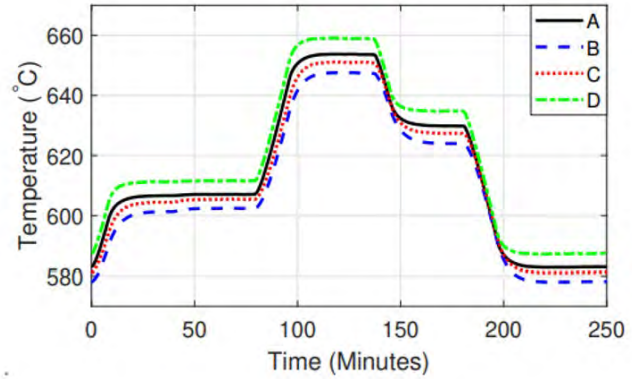
Power Transient Testing: Results



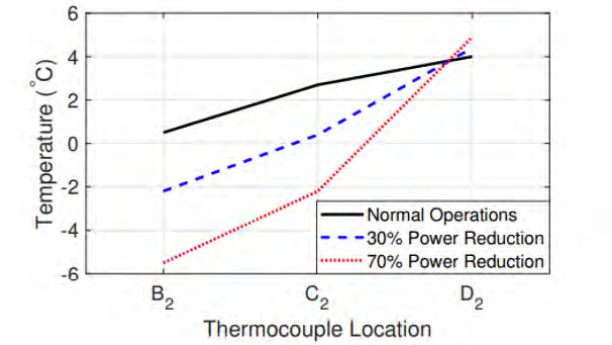
Normal operation temperature at various TC locations



Abnormal operation at 30% power reduction from normal at various TC locations



Abnormal operation at 70% power reduction from normal at various TC locations



Average temperature differences between thermocouples references to TC A_2

Thermocouple	B_2	C_2	D_2
Normal Operations [ΔT °C]	0.5	2.7	4.0
30% Power Reduction [ΔT °C]	-2.2	0.4	4.4
70% Power Reduction [ΔT °C]	-5.5	-2.2	4.9

Average temperature differences between thermocouples references to TC A_2

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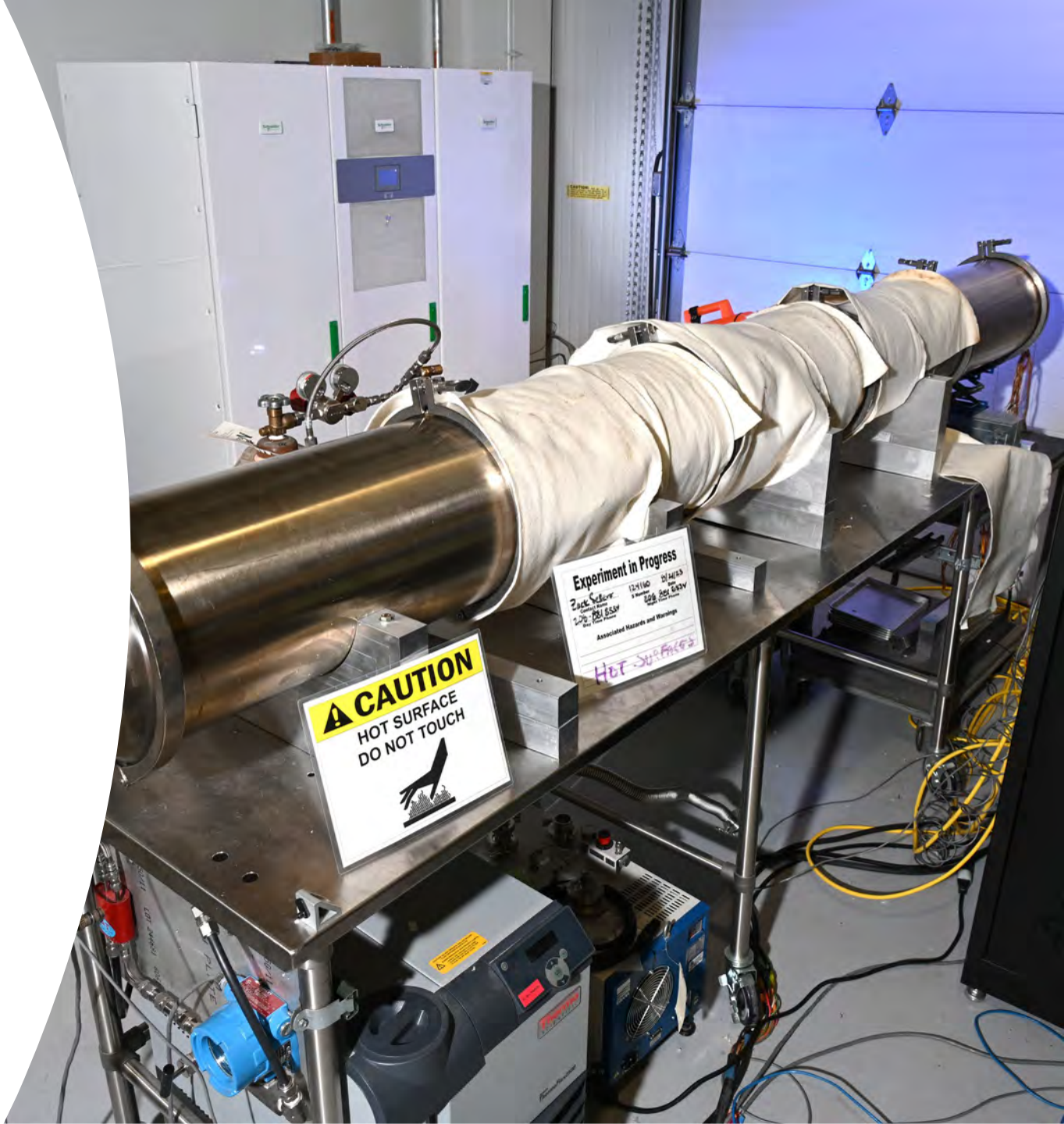
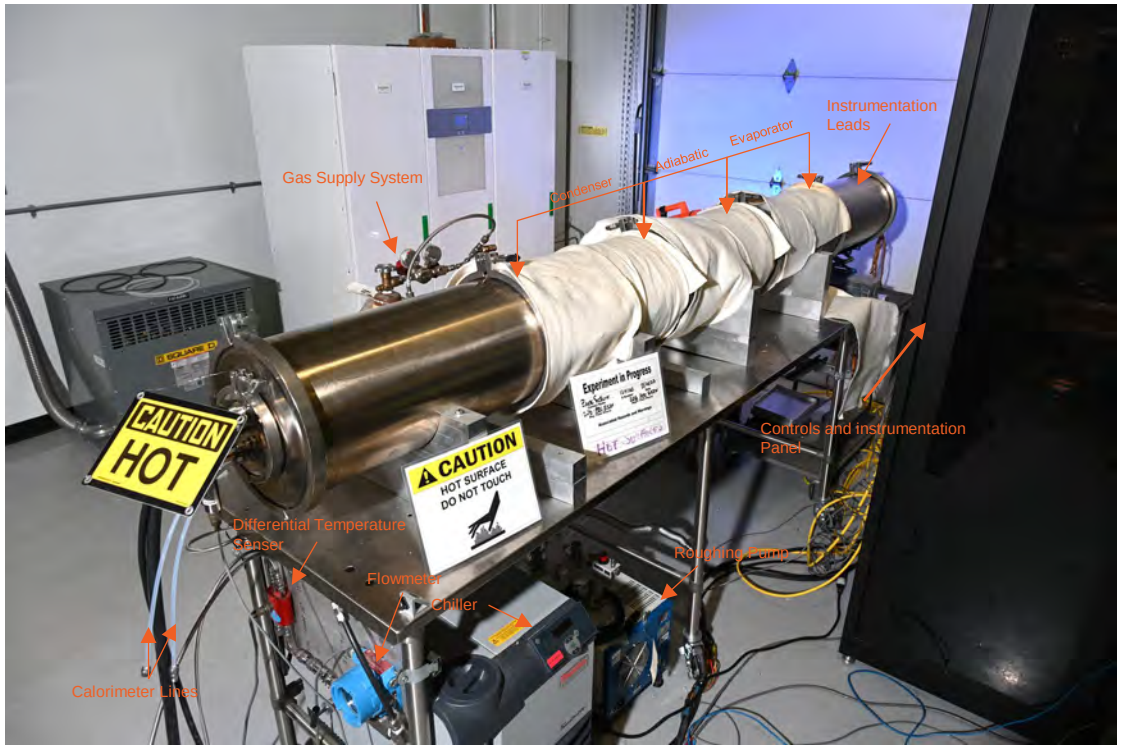
FY 24 Summary: SPHERE Long Duration Testing

- Idaho National Laboratory has completed testing over a long duration of a high-performance sodium filled heat pipe while monitoring axial temperature profile, power supplied by the heaters, and heat removed by a gas-gap calorimeter. The results from this testing can aid in heat pipe validation efforts.



SPHERE Long Duration Testing: Test Overview

- Stainless steel sanitary tubing test setup
- Instrumentation
  - Thermocouples
  - Calorimeter
    - Flowmeter and differential temperature sensor
  - Watt transducers
- Ceramic fiber heaters
- Broken up into two portions of testing



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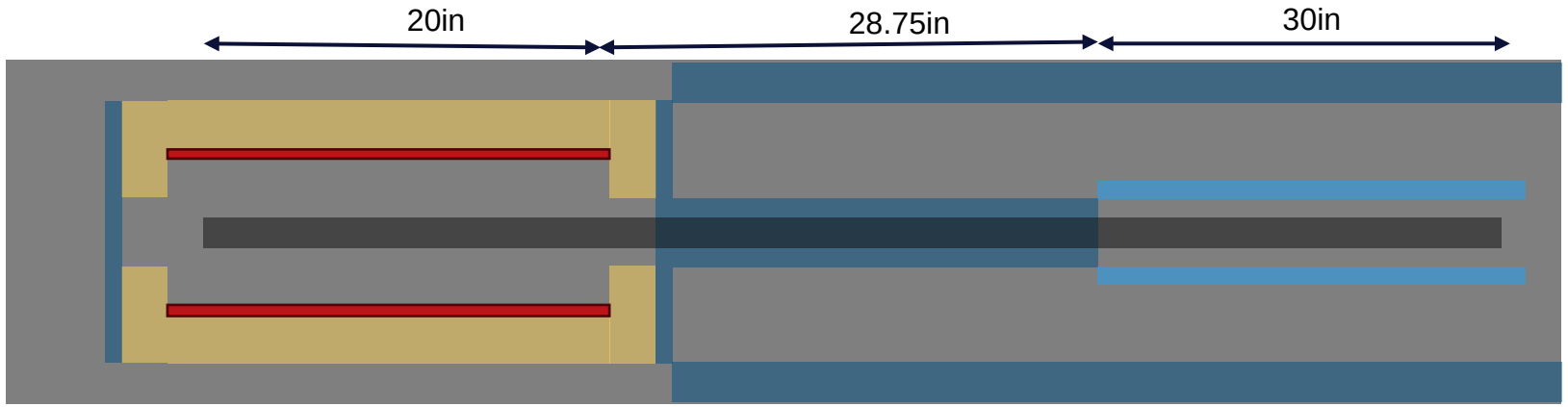
SPHERE Long Duration Testing: Setup

- Overview Diagram:



Ceramic fiber heater

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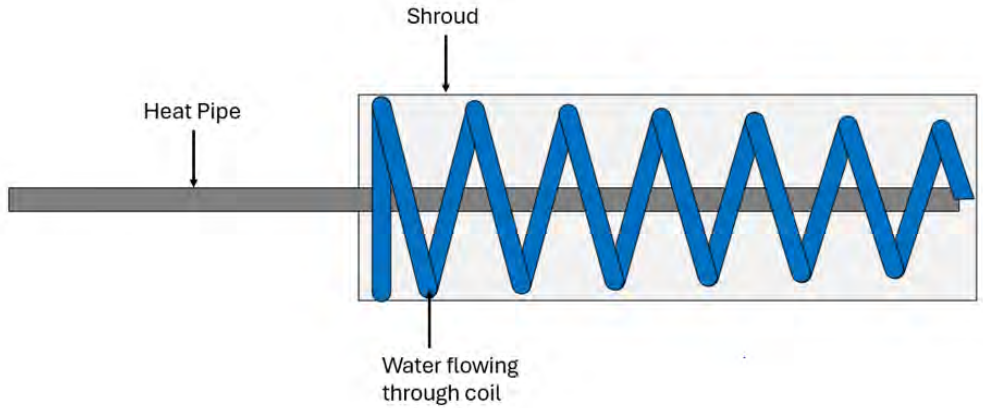
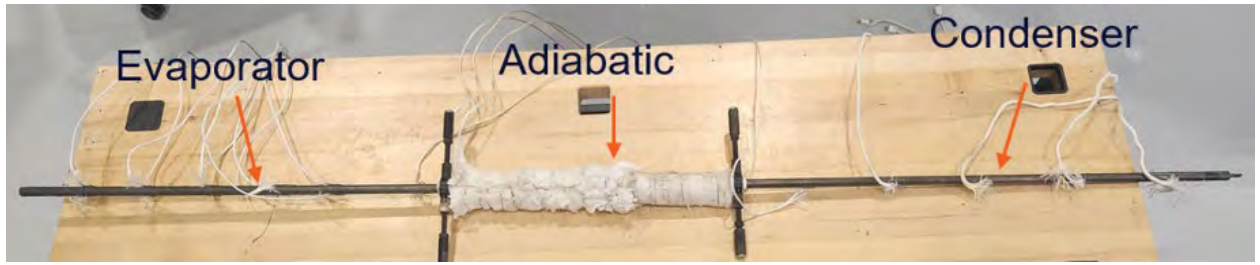
SPHERE Long Duration Testing: Test Setup

- Calorimeter Overview:



- Heat Pipe Instrumentation Layout



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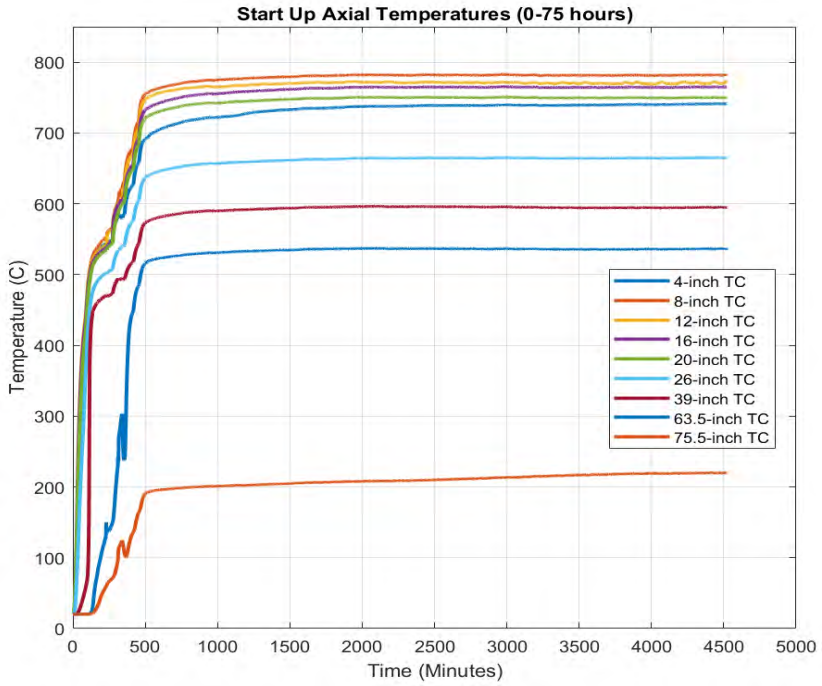
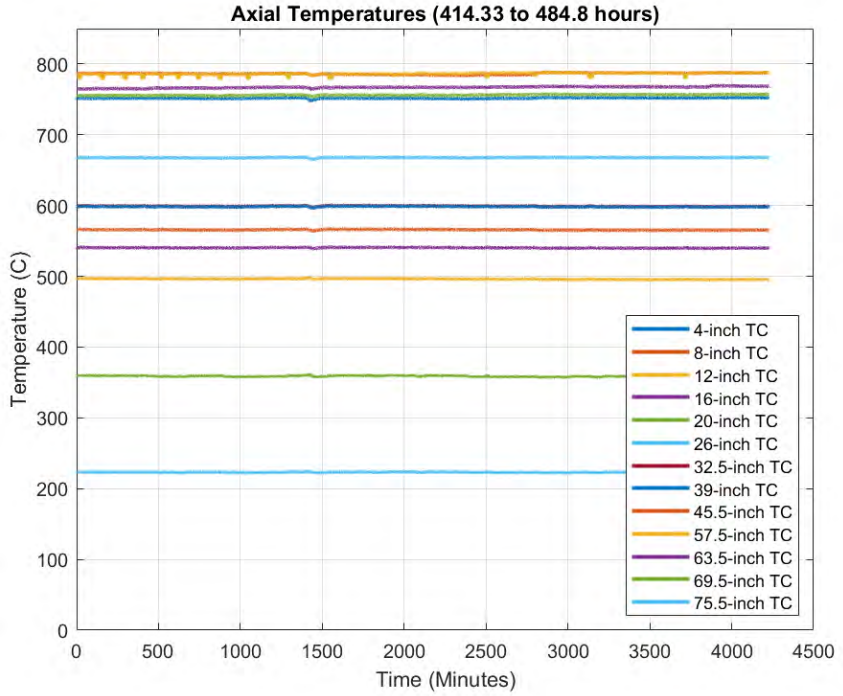
SPHERE Long Duration Testing: Results





Location	Temperature (°C)	
	Startup	End of first stage
Minimum (75.5-inch)	209.7	222.7
Maximum (8-inch)	781.4	787.5
Evaporator Exit (20-inch)	749.6	756.8

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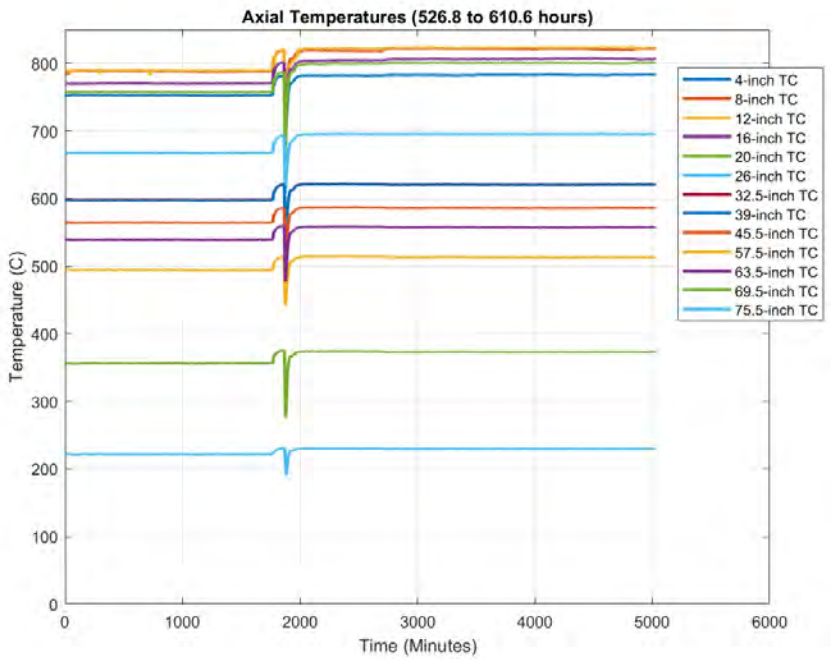
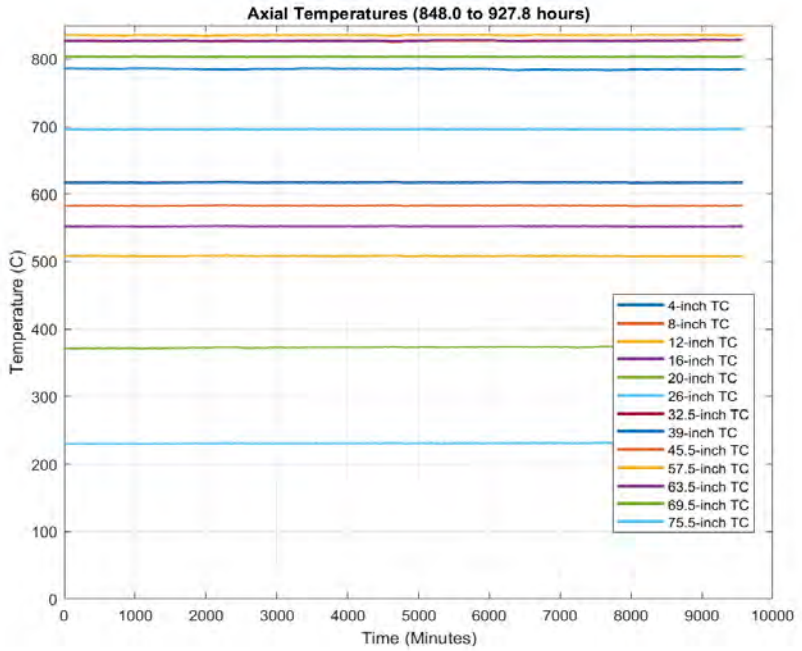
SPHERE Long Duration Testing: Results





Location	Temperature (°C)	
	Beginning of Stage Two	End of Testing
Minimum (75.5-inch)	230.4	231.8
Maximum (8-inch)	822.3	824.0
Evaporator Exit (20-inch)	800.5	800.5

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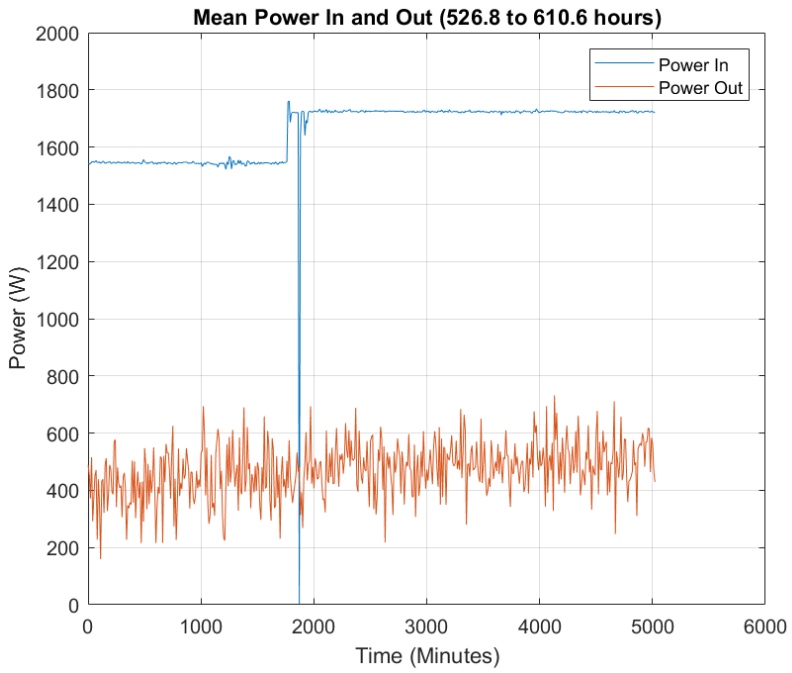
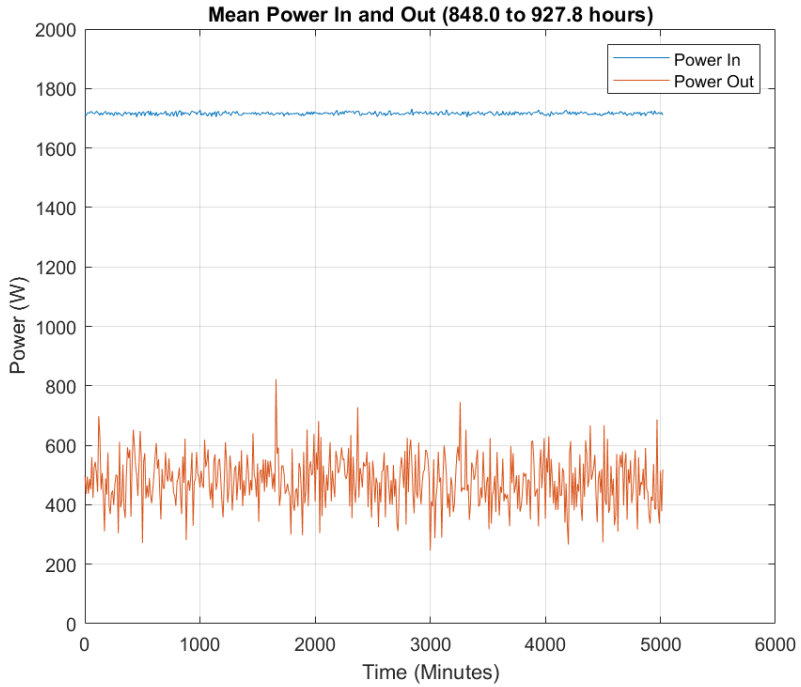
SPHERE Long Duration Testing: Results





	Startup	End of testing
Average Power In (W)	1722.8	1718
Average Power Out (W)	488.3	479.0

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SPHERE Long Duration Testing: Conclusion

- The long duration testing resulted in minimal differences between the beginning and end results for both stages. The long duration steady state test data was provided to the Sockeye development team for validation efforts for heat pipe modeling.

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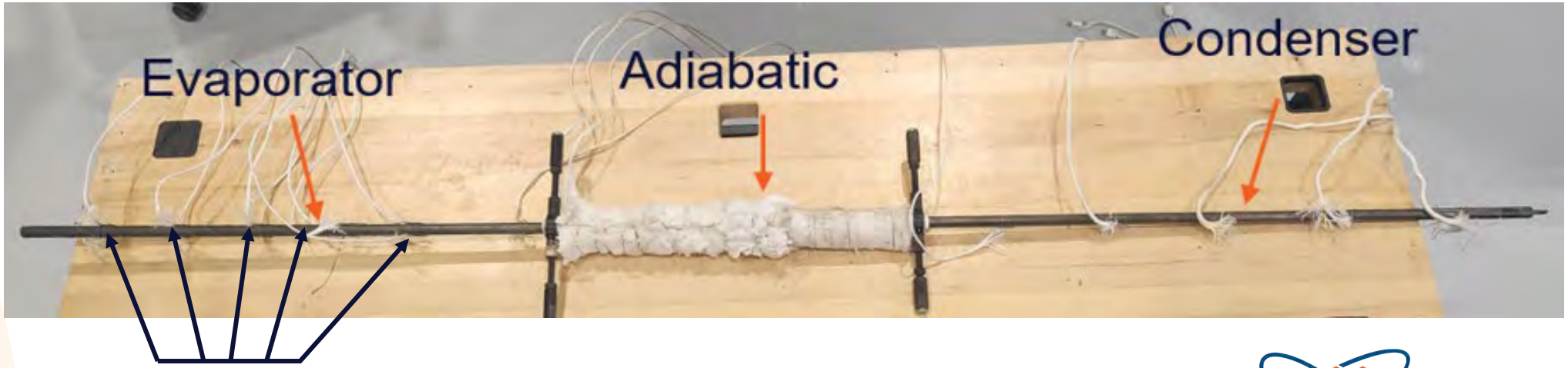
SPHERE Long Duration Configuration Test Update

- Plan to rerun the test with the updated configuration based on ACT feedback in early March
- Insulated the thermocouple junctions with silver paste to reduce radiative heat transfer affecting the temperature readings on the evaporator region



Junctions with silver paste applied

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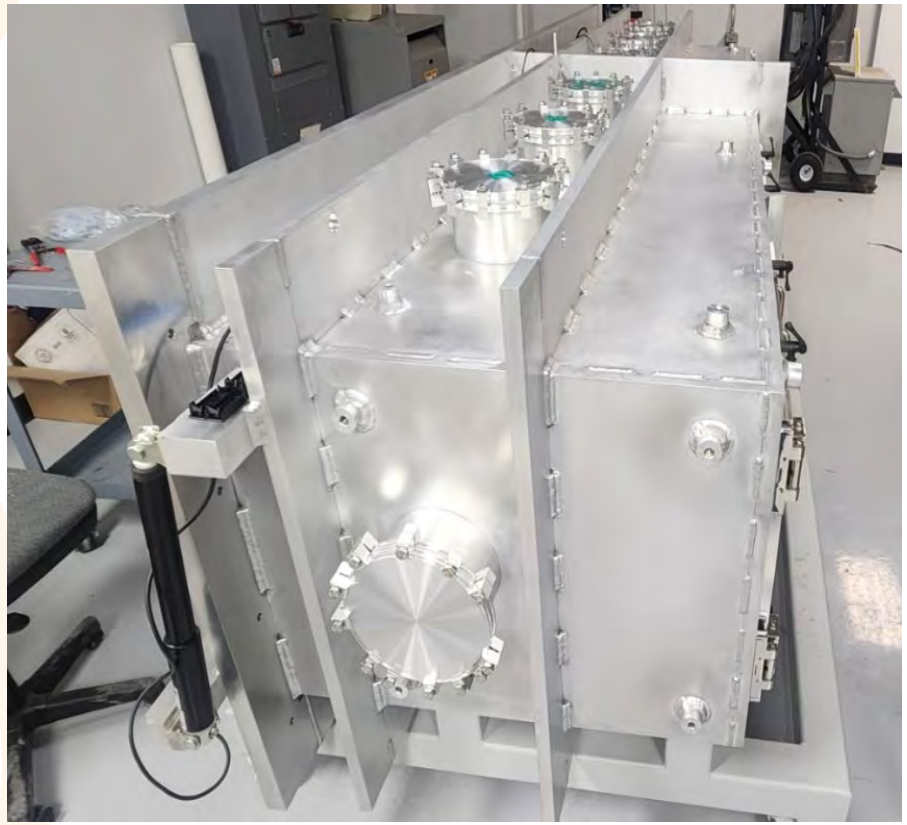
Vacuum Chamber Updates

- Tasks for March/April
  - Obtain achievable level of vacuum
  - Plans to implement LANL heat pipes into the chamber
    - Stainless steel heat pipe test as both system shakedown and to gain experience testing before the moly heat pipe arrives



FY25 Milestones

- Develop a targeted phenomena identification and ranking table (PIRT) for heat pipes
  - 4/01/25
- Perform vacuum boundary condition heat pipe analysis
  - 5/28/25
- Complete testing on refractory metal heat pipe from Los Alamos National Lab
  - 7/31/25
- Complete transient testing on a high-performance heat pipe approaching operating limits
  - 9/10/25

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