Single Primary Heat Extraction and Removal Emulator (SPHERE)

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MRP Microreactor Program

SPHERE Background

- Provide data to SOCKEYE to assist with model verification and validation
- Provide MAGNET with initial testing expertise
  - Small scale experiments to gain understanding and work out any issues before installing into the larger system
- Provide costumers/venders with a low cost, versatile test bed

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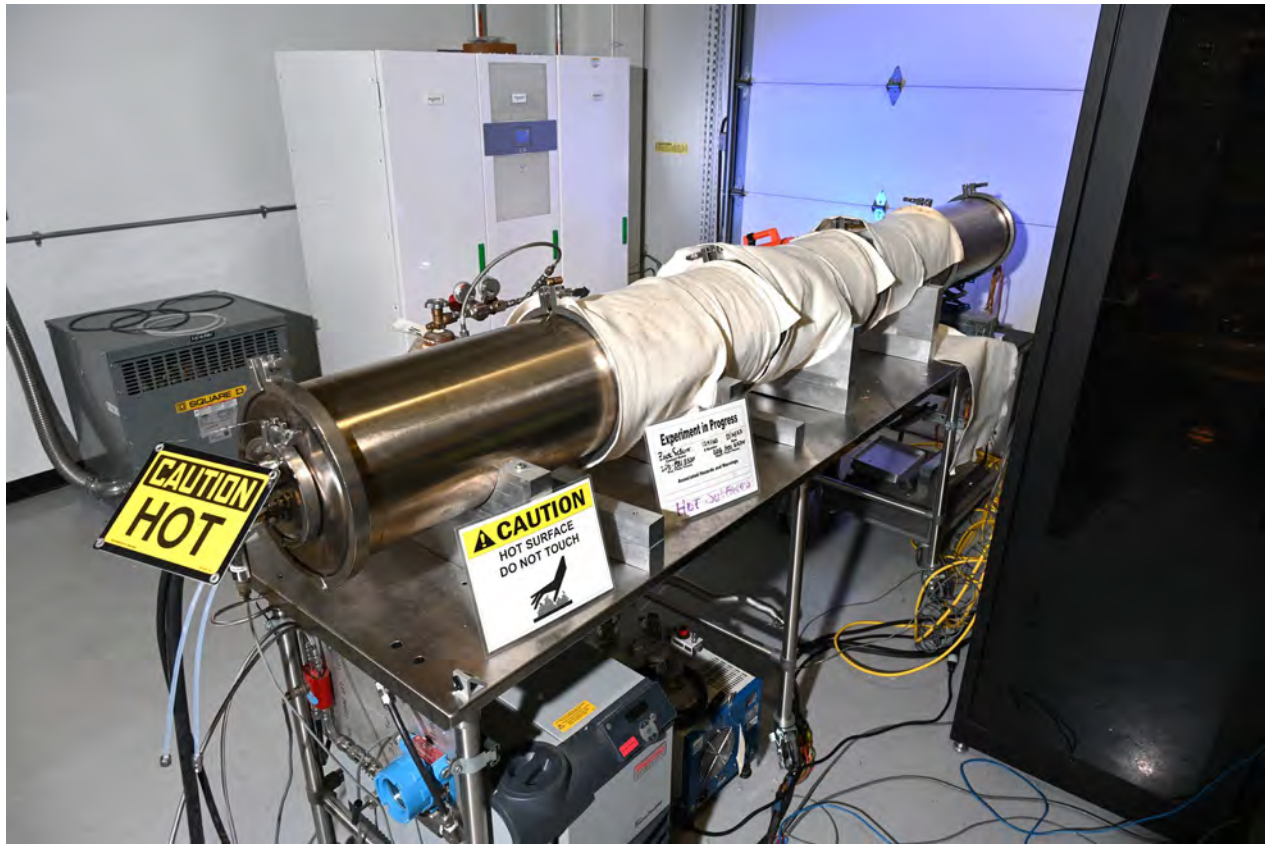
SPHERE Sanitary Tube Configuration



Parameter	Value
Length	10 ft
Diameter	12 in
Connections	Flanged for gas flow and instrumentation feedthroughs
Maximum Power	20 kW
Maximum Temperature	900 C
Heat Removal	Passive radiation or water-cooled gas gap calorimeter
Environment	Inert gas (1atm), Vacuum (~10Torr)

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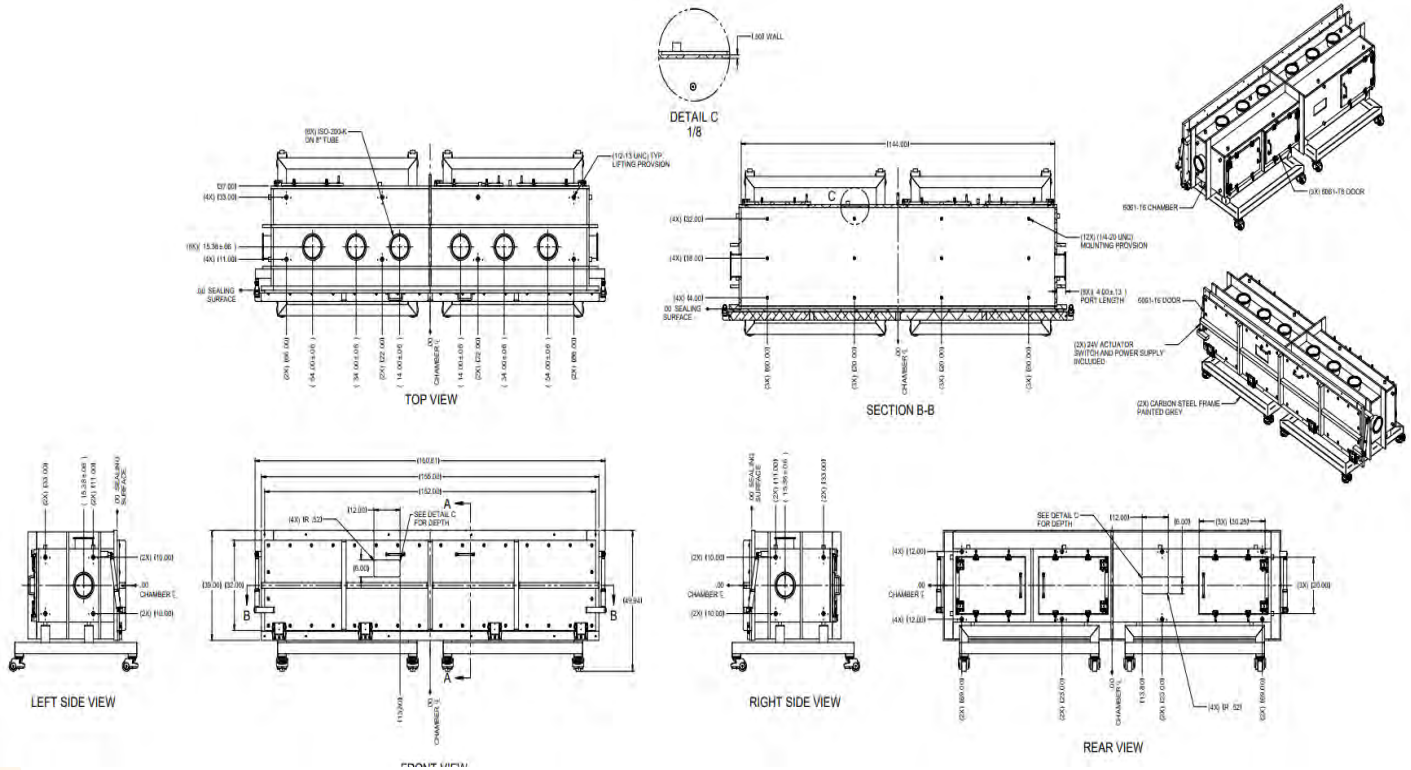
SPHERE Vacuum Chamber Setup



Parameter	Value
Length	13 ft
Cross-section	2 ft x 3 ft
Connections	Flanged for gas flow and instrumentation feedthroughs
Maximum Power	20 kW
Maximum Temperature	900 C
Heat Removal	Passive radiation or water-cooled gas gap calorimeter
Environment	Inert gas (1atm), Vacuum (~10^{-4}Torr)

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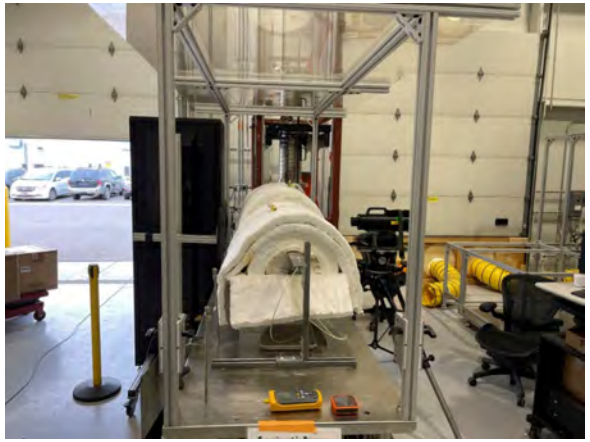
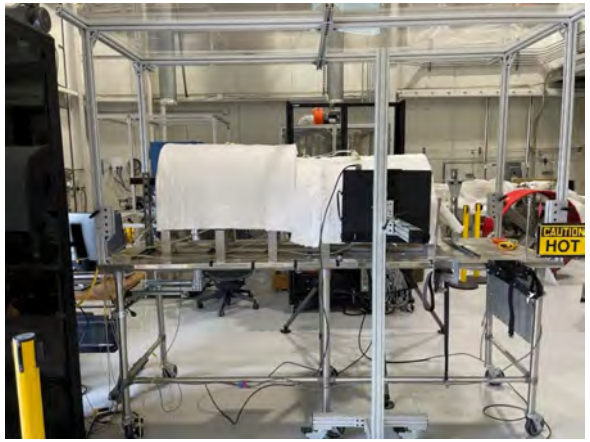
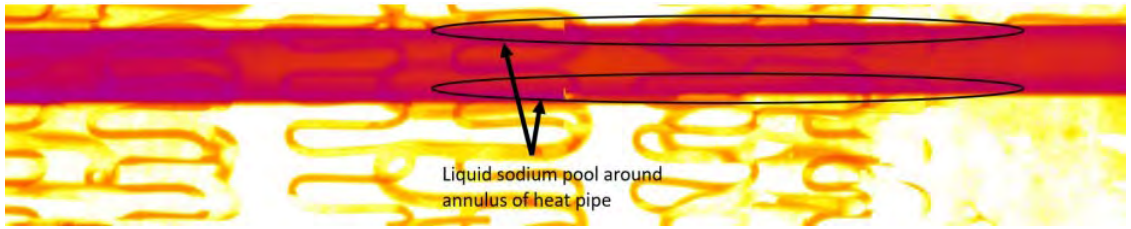
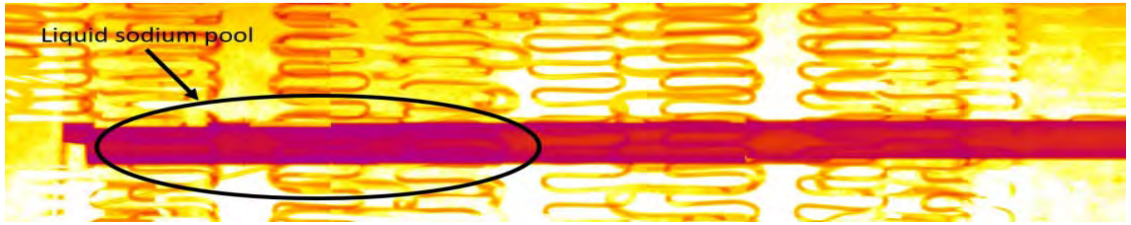
SPHERE FY23 Achievements

- In-operando x-ray testing of sodium filled heat pipes
- Expanded capabilities to be able to perform open air testing
- Expanded vacuum capability for the SPHERE testbed









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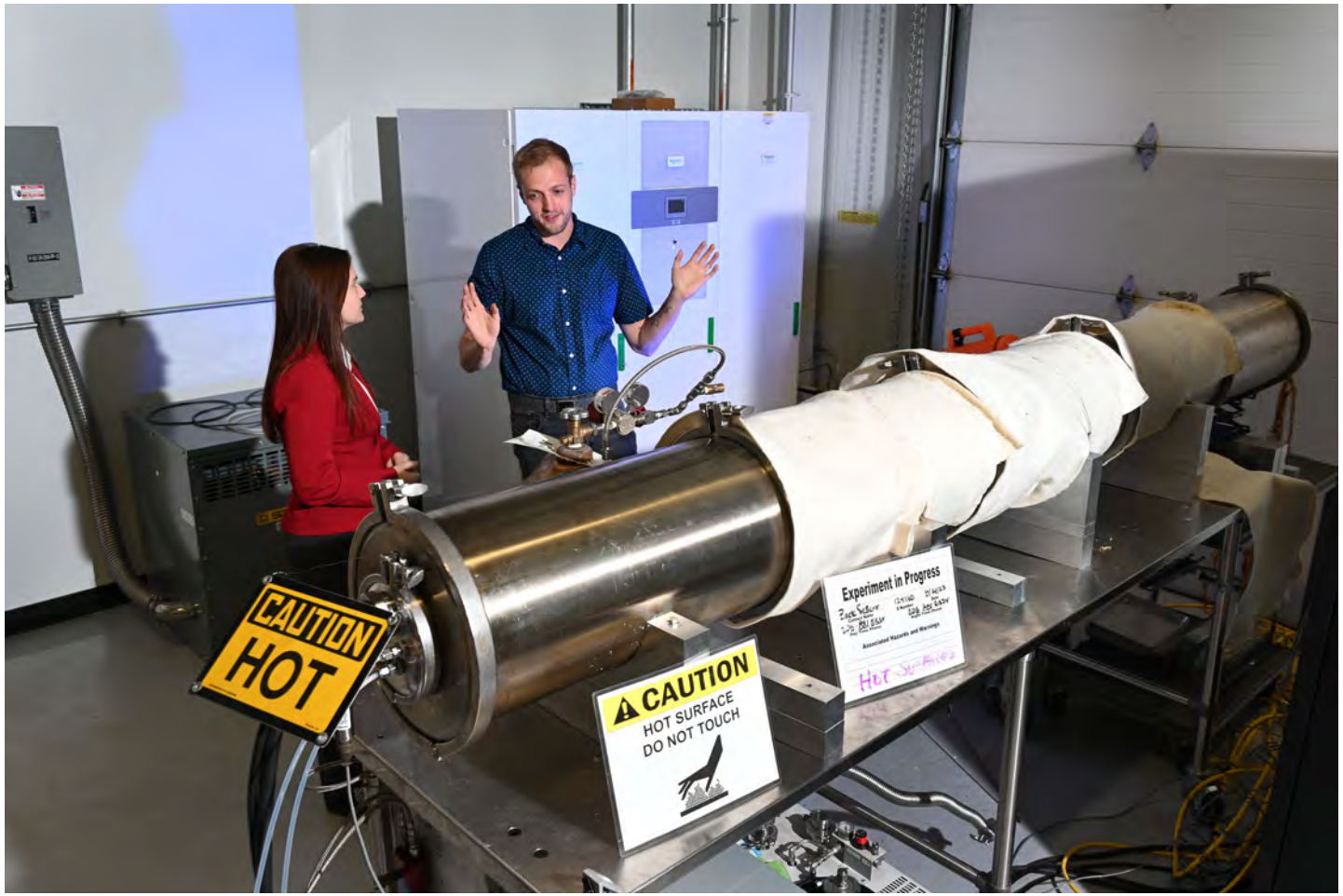
Power Transient Testing: Objective

- 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



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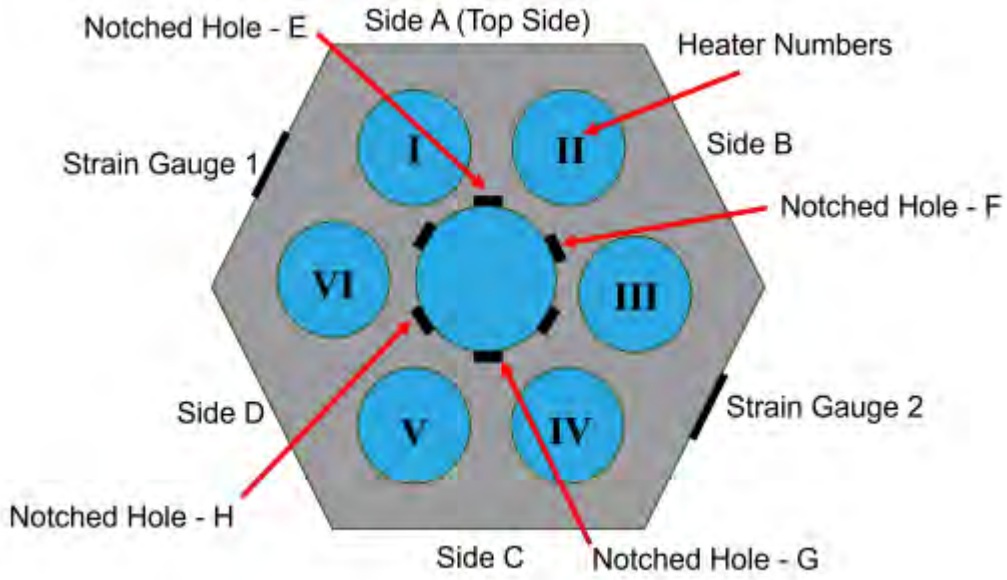
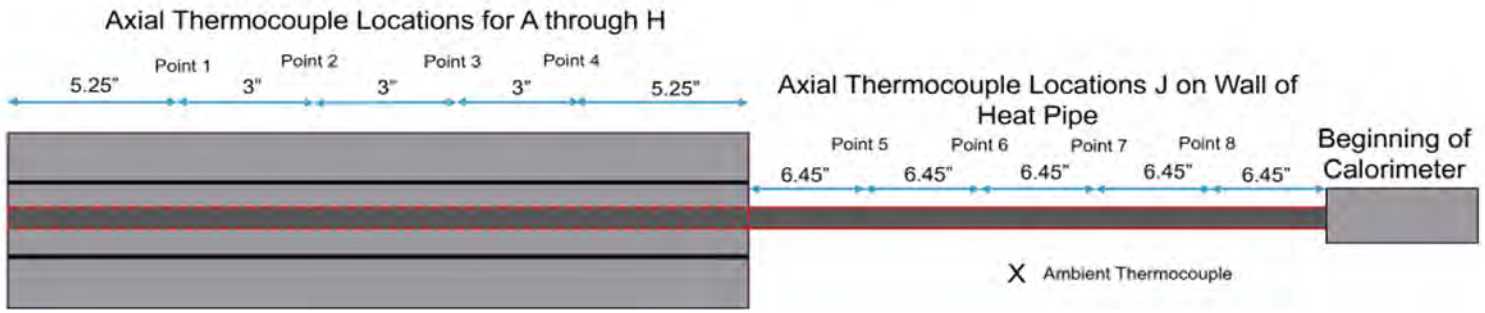
Power Transient Testing: Test Setup

- 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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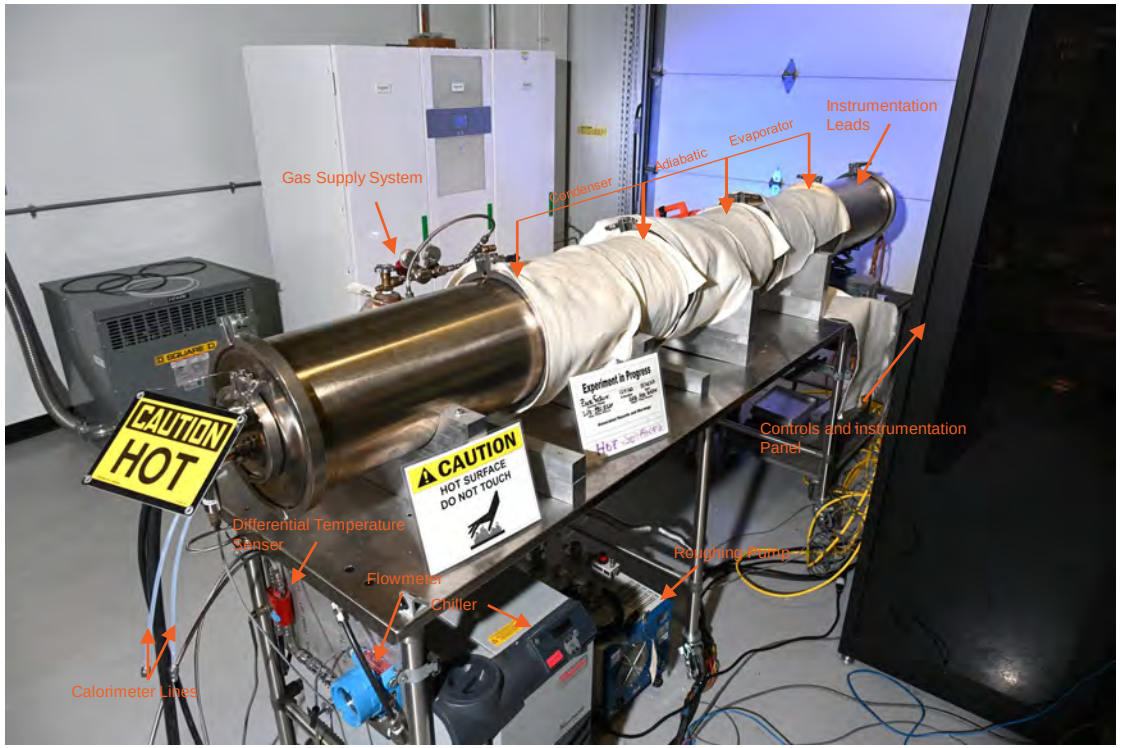
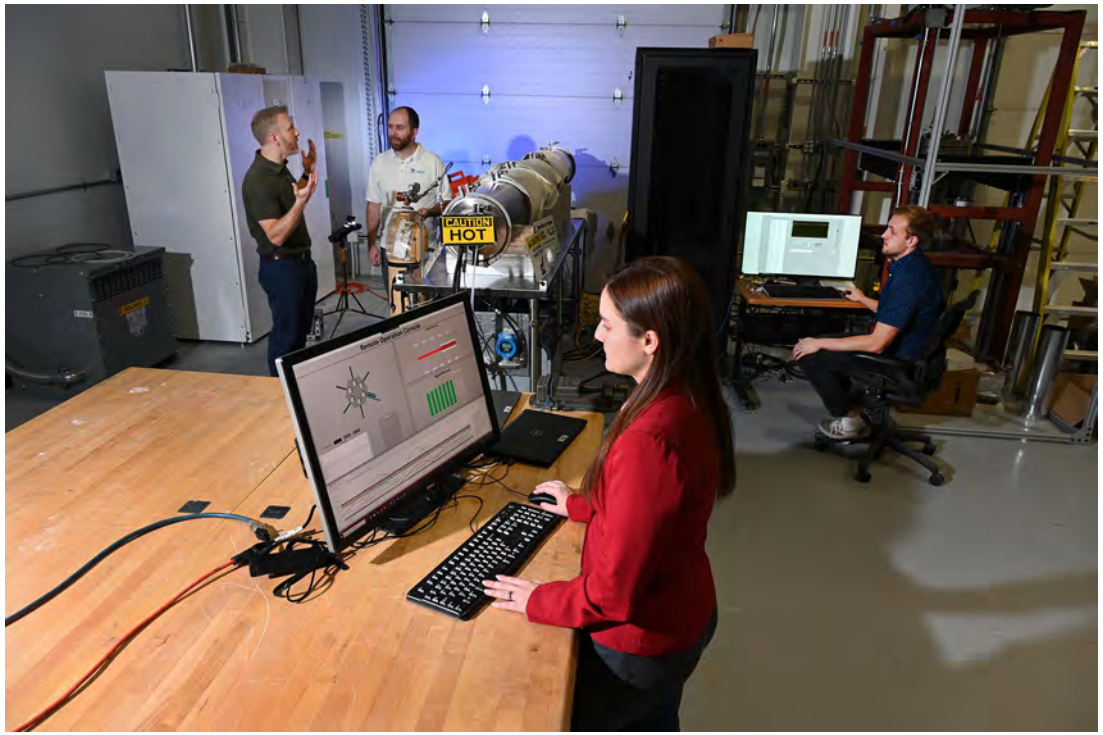
Power Transient Testing: Test Setup





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Power Transient Testing: Test Plan

- Purge system of air and backfill with nitrogen
- Ramp rate of 5C/min
- Once condenser region reaches working temperature, calorimeter started
- Work through test matrixes

Temperature	Hold Time
600°C	0.5hr
625°C	0.5hr
675°C	0.5hr
650°C	0.5hr
600°C	0.5hr
625°C	0.5hr
675°C	0.5hr
650°C	0.5hr
600°C	0.5hr

Temperature	Hold Time
600°C	10 min
625°C	10 min
675°C	10 min
650°C	10 min
600°C	10 min
625°C	10 min
675°C	10 min
650°C	10 min
600°C	10 min

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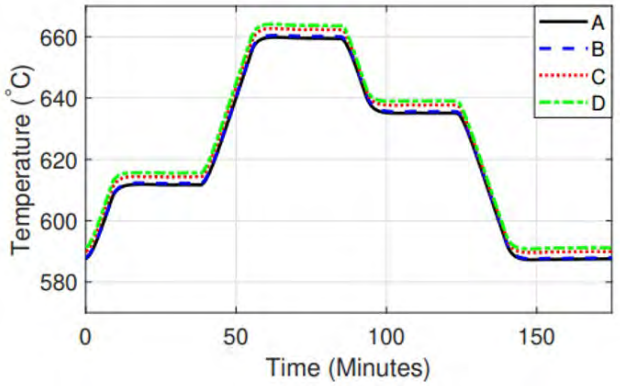
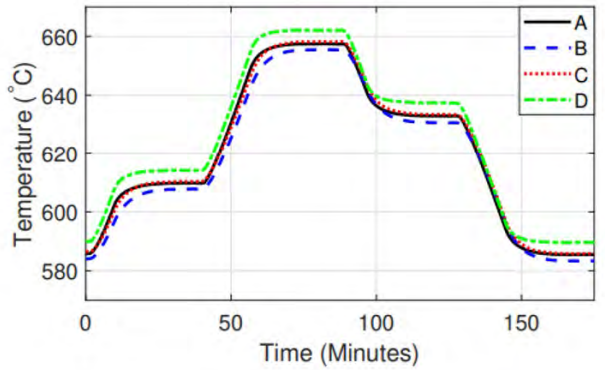
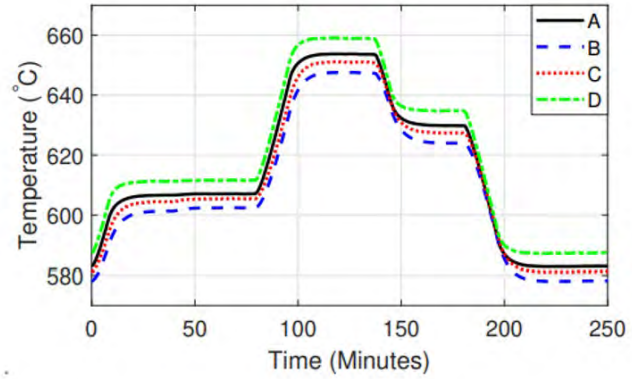
Power Transient Testing: Results



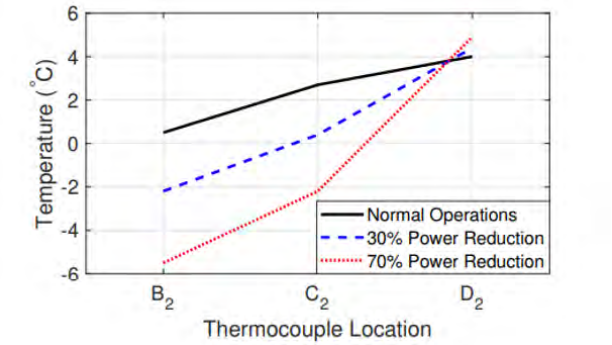
Normal operation temperature at various TC locations



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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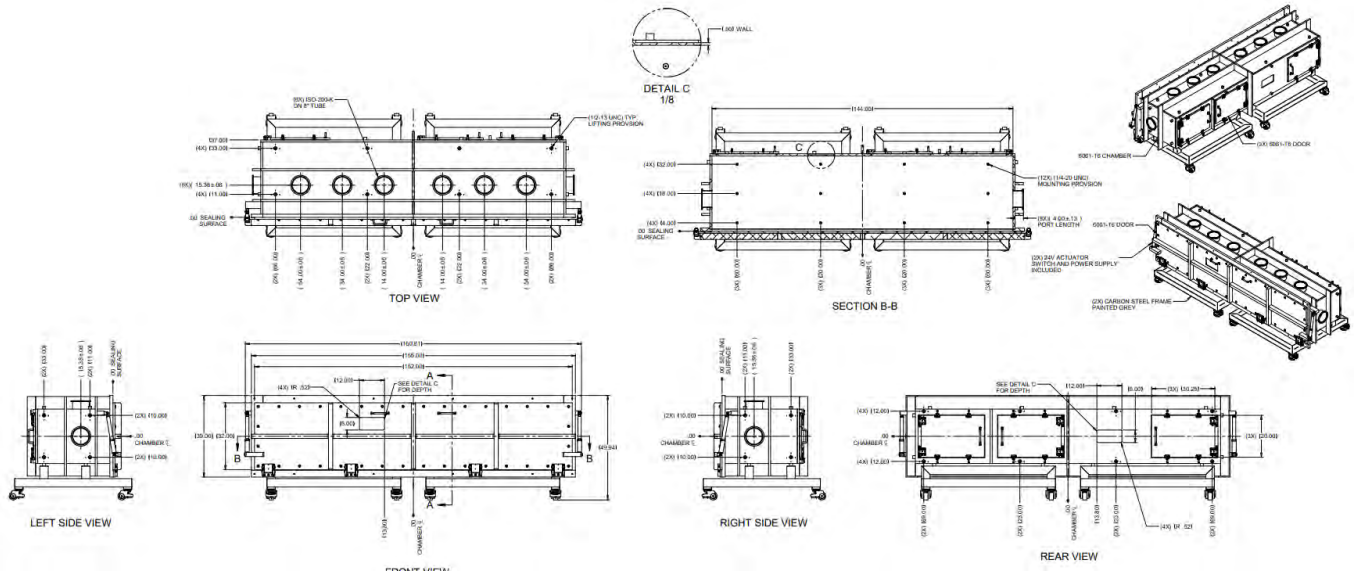
Power Transient Second Experiment: Objectives

- Current Issue: Under defined boundary conditions

- Solution
  - Utilize new vacuum chamber ($10^{-4} torr$)
  - Utilize radiative insulation for both the evaporator and adiabatic region



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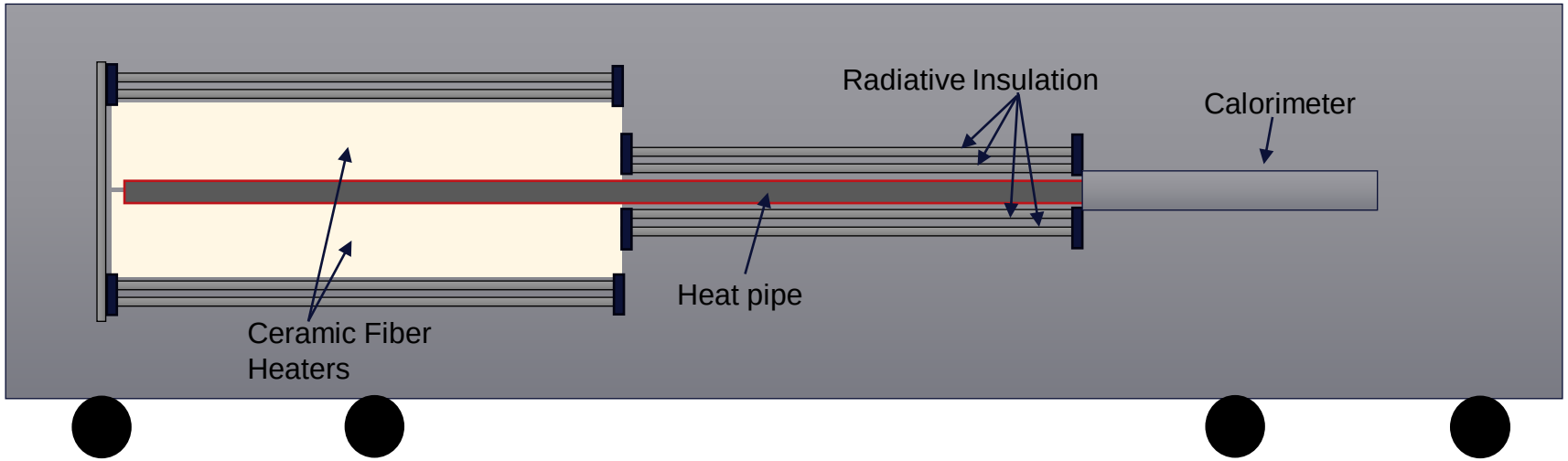
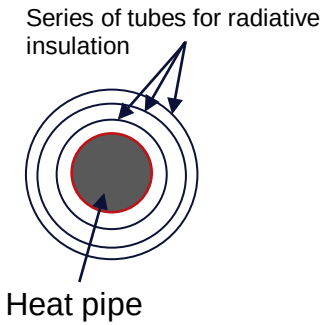
Power Transient Second Experiment: Test Setup





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LANL Heat Pipe Testing

- Los Alamos to ship refractory metal heat pipe by middle of March
- Work with Los Alamos National Laboratory to develop test plan
- Perform testing by end of June
  - As of now to be tested in sanitary tube setup
  - If secondary power transient testing is setup, option for either test bed to perform testing

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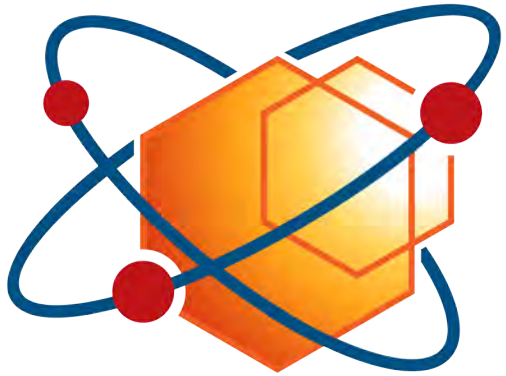

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