MAGNET Brayton Cycle PCU Integration

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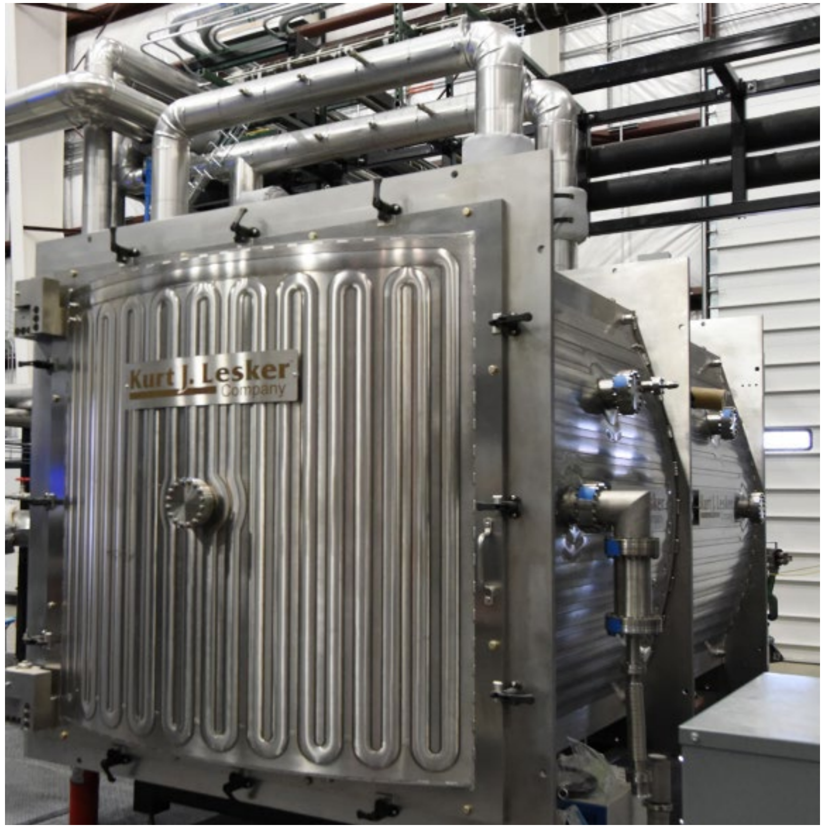
MAGNET Overview

MAGNET is designed to provide a facility for researchers and technology developers to test microreactor concepts in a relevant environment to advance technical maturity.

Design Specifications:

- Consists of a 5ft x 5ft x10ft chamber with water cooled walls and a variety of ports and feed-throughs to enable testing under vacuum and inert conditions up to 1 atm.
- Electrically heated to provide up to 250KW of electrical power to heaters.
- Maximum test article temperature of approximately 750 ℃ .
- Collant loop designed to remove up to 250 kWth using air, nitrogen or helium as the coolant. Design pressure of coolant loop is 22 barg with a design temperature of 650℃.
  - Nitrogen Mass flow up to 0.07 kg/s
  - Helium Mass flow rates up to 0.07 kg/s.



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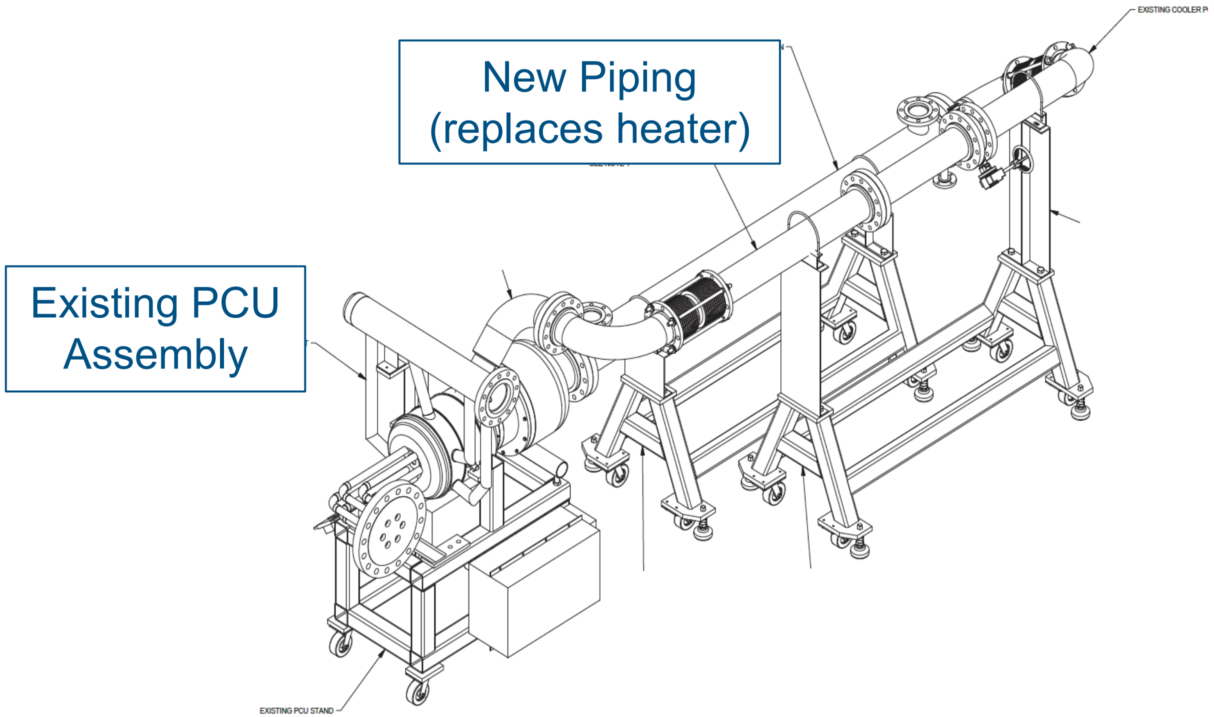
PCU Integration Objective

- Advance MAGNETs capabilities by installing and preforming an initial shake down on a power conversion unit (PCU).
  - Piping, structural, and electrical construction designs complete (FY 25)
  - The PCU, which operates on a closed Brayton cycle, significantly enhances MAGNET's capabilities by demonstrating coupled power conversion system with a simulated microreactor (MAGNET), setup limited to 30kW



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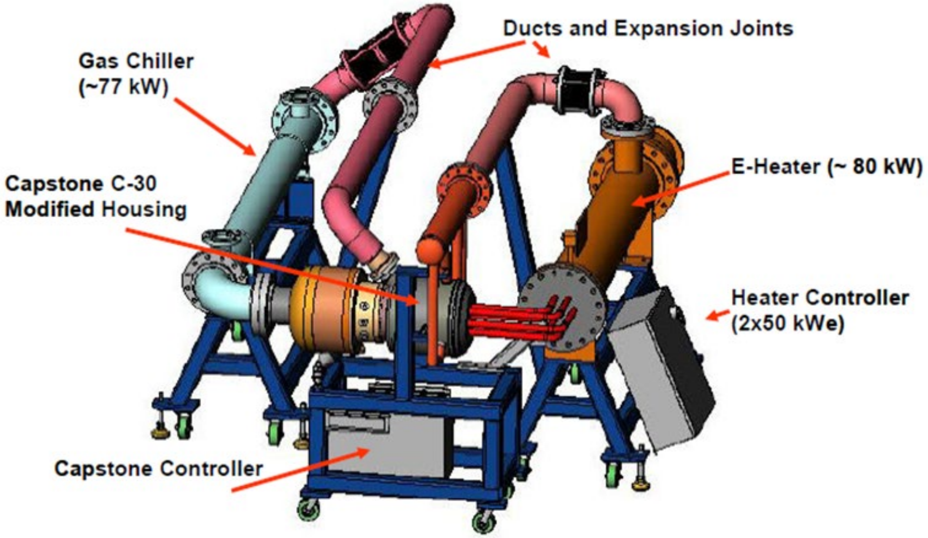
Background

- In 2021, the PCU hardware was transferred from SNL to INL after a period of inactivity.
  - Hardware was modified and ~150ft of piping was added to enable integration with MAGNET
  - Construction was completed on 5/23/2025.

MAGNET Control Station and Environmental Chamber



Assembly Drawing of Original PCU Hardware

Portion of Added Piping

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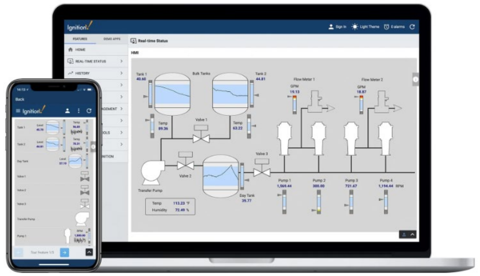
MAGNET Control System

- Control System - Hardware & Software
  - Data Acquisition System: *groov*EPIC controller by Opto 22
  - Software Interface: PAC Control by Opto 22
  - Human Machine Interface (HMI) Software: Ignition by Inductive Automation

MAGNET Data Acquisition System

MAGNET HMI Software

Ignition
by inductive automation



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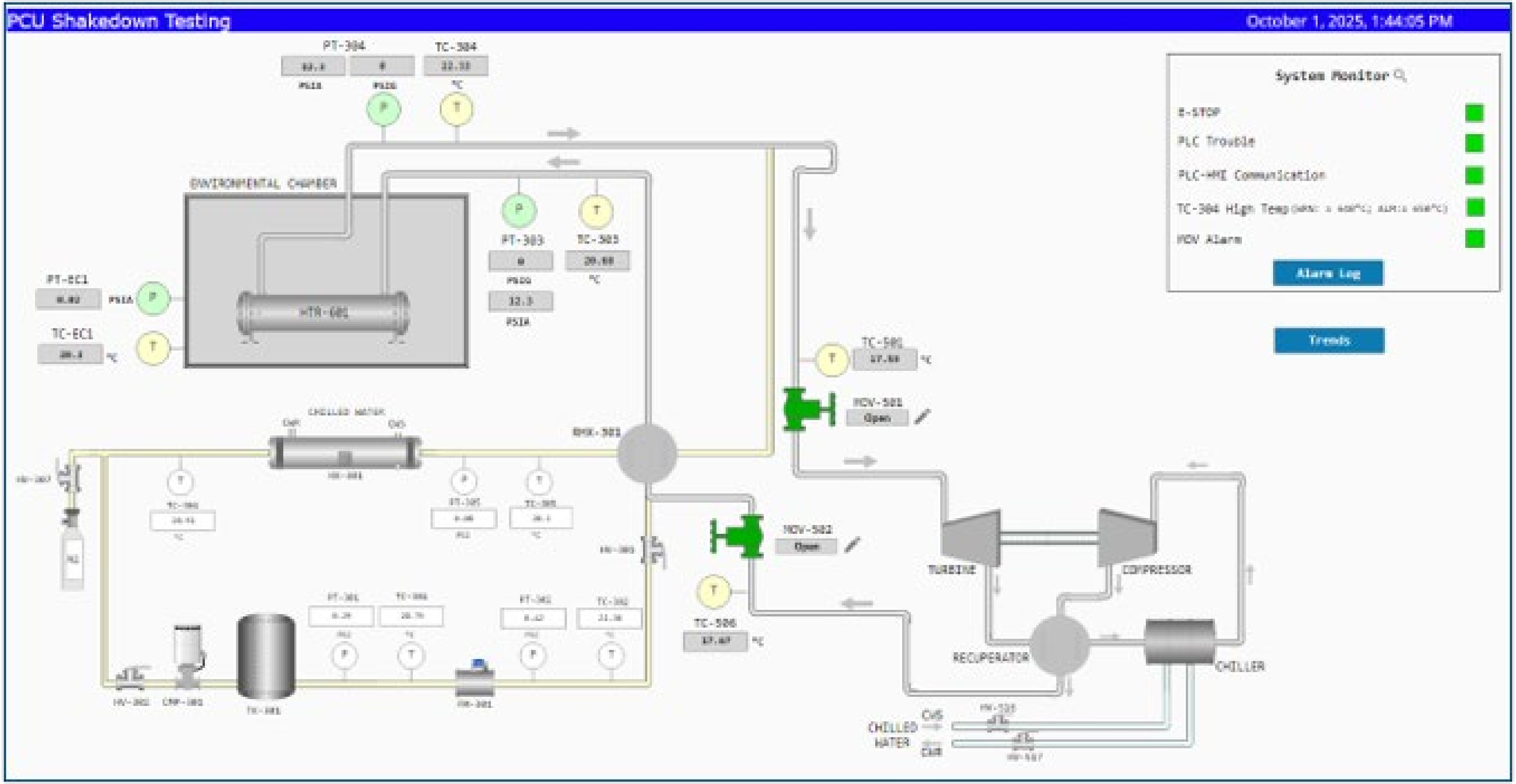
PCU Instrumentation and Controls

PCU HMI



PCU Shakedown Testing

Test#	Date	Conditions	Findings	Outcome
1	Sep 24, 2025	50 psig fill pressure	A faulty contactor burned out the turbine EMI Boards.	Contactor issue fixed
2	Sep 29, 2025	15 psia (~2.8 psig), N_2 fill	Low gas flow; piping restriction	Upgraded to 2” piping
3	Nov 3, 2025	10 psig, upgraded piping	Insufficient mass flow rate to transfer heat; 70 °C gradient	Revised test plan to include pre-heat
4	Nov 10, 2025	10 psig, preheat to 200 °C	Insufficient mass flow rate; turbine inlet increased to 30 °C	Optimized heater performance within PCU pressure limits.
5	Nov 18, 2025	40 psig, preheat to 360 °C	Turbine inlet reached 200 °C; very slow heat-up (0.5 °C/min)*	Perform flow modeling and simulation to assess the viability of these two options.

* At this heat up rate it would take approximately 19 hours to reach the required 600°C for the turbine to generate power

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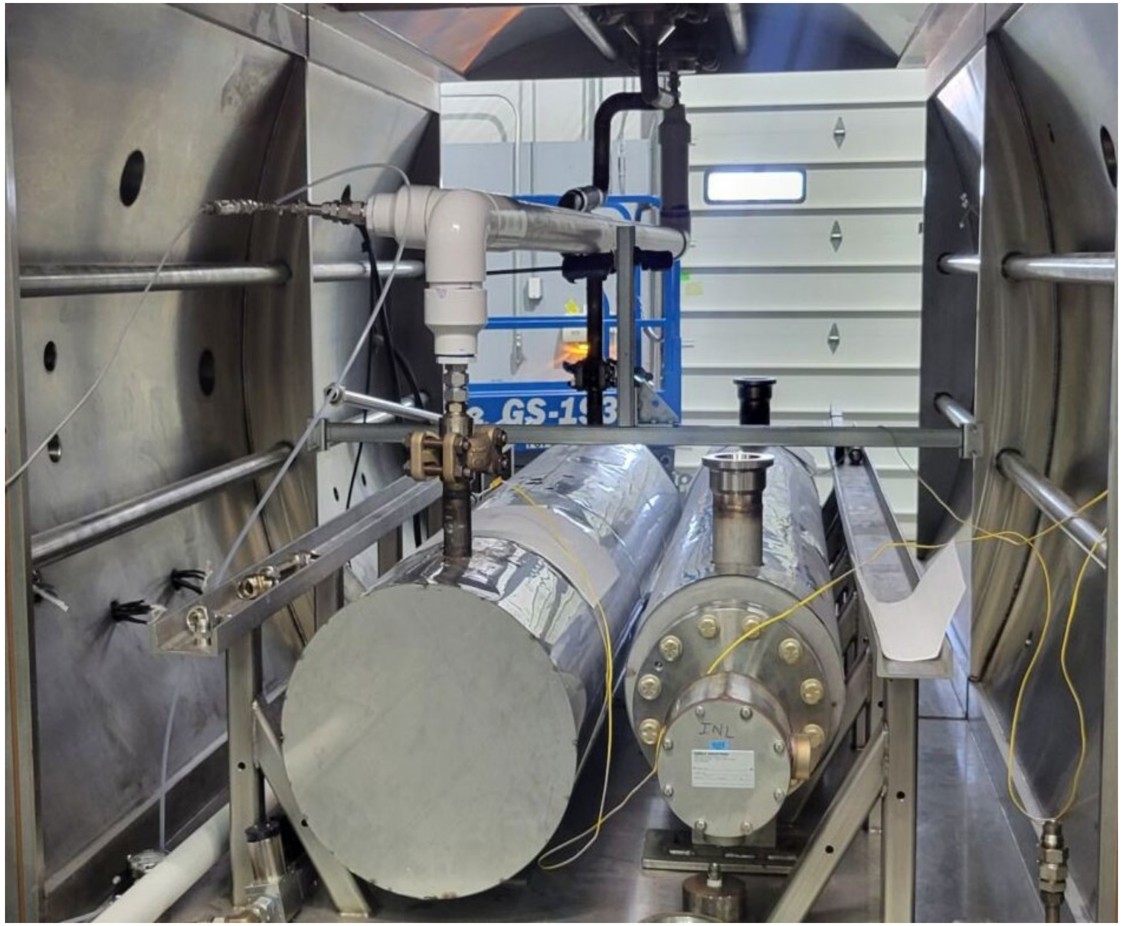
PCU Shake Down Tests

Original 1” Tubing

1” tubing resulted in pressure drop that exceeded the capacity of the PCU compressor

Modified 2” Tubing Test



PVC used to demonstrate and subsequently replaced with stainless steel tubing

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Modeling Results

- Without accurate flow rate measurements, system is currently operated without adequate operational insight.
- Flow orifice was sized at the large end for full system flow rate
  - Operating cold at only 3.5 kW, that orifice size shows zero pressure drop
  - Ordered smaller flow orifice to have reliable flow indication at lower flow rates
- Model variations indicated significant uncertainty (mostly due to lack of reliable flow rate indication)
- One version shows possible problems with the internal recuperator with results closely matching test run heater input power
  - Again, lack of reliable flow rate indication is the likely culprit
  - But it is also possible that the recuperator is fouled
- The addition of the original PCU heater, at the turbine inlet, will allow full turbine inlet temperature and full shaft speed
- The only questionable outcome is whether we can turn off the “booster” heater after steady state is achieved.

Next Steps for the PCU Integration Test

- Obtain cost estimates for addition of “booster” heater
- Install “booster” heater
- Install smaller orifice plate for reliable flow rate indication
- Run shakedown testing
  - During shakedown testing, verify that “booster” heater can be shut off once PCU reaches steady state condition
- If time and funding is available, further develop controls to automate the startup process for future integrated system testing

Graphite Test Article Performance Testing

Objective

- Test the LANL manufactured Graphite Test Article in MAGNET.
- Show the heat pipes are transferring at least 1.2 kW heat at a nominal operating temperature between 750°C to 800°C.

Significance

- Testing an industry relevant graphite core heat pipe cooled design it serves as a controlled, scalable test platform to validate thermal management technologies before full-scale deployment.

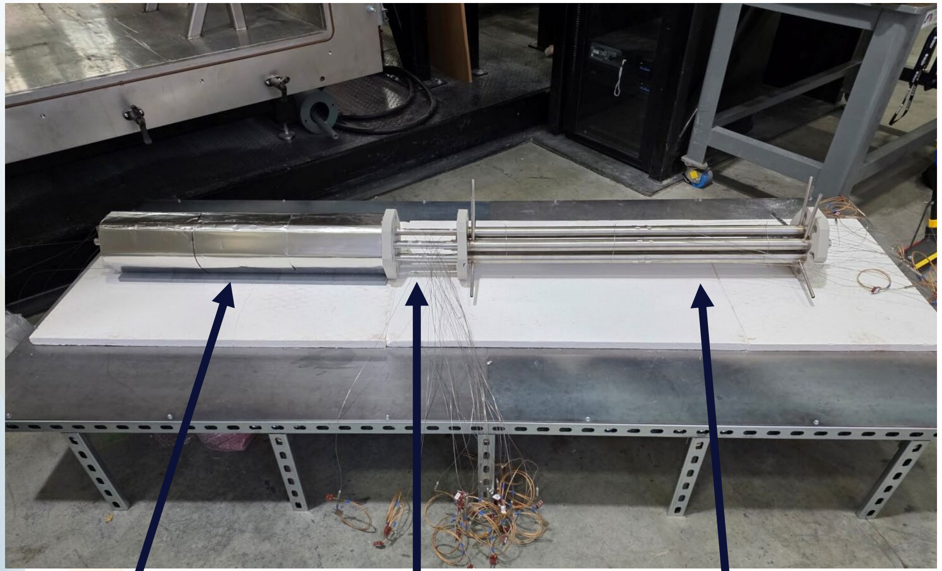
Test Article Description

- Three 10-inch-long graphite blocks
- Twelve 1.8 kWth heaters
- 7 LANL high performance heat pipes
- 7 LANL gas gap heat exchangers using helium as coolant.

LANL Graphite Assembly Test

Installed in MAGNET, testing planned to be completed by end of February 2026.

Test article before installation into MAGNET

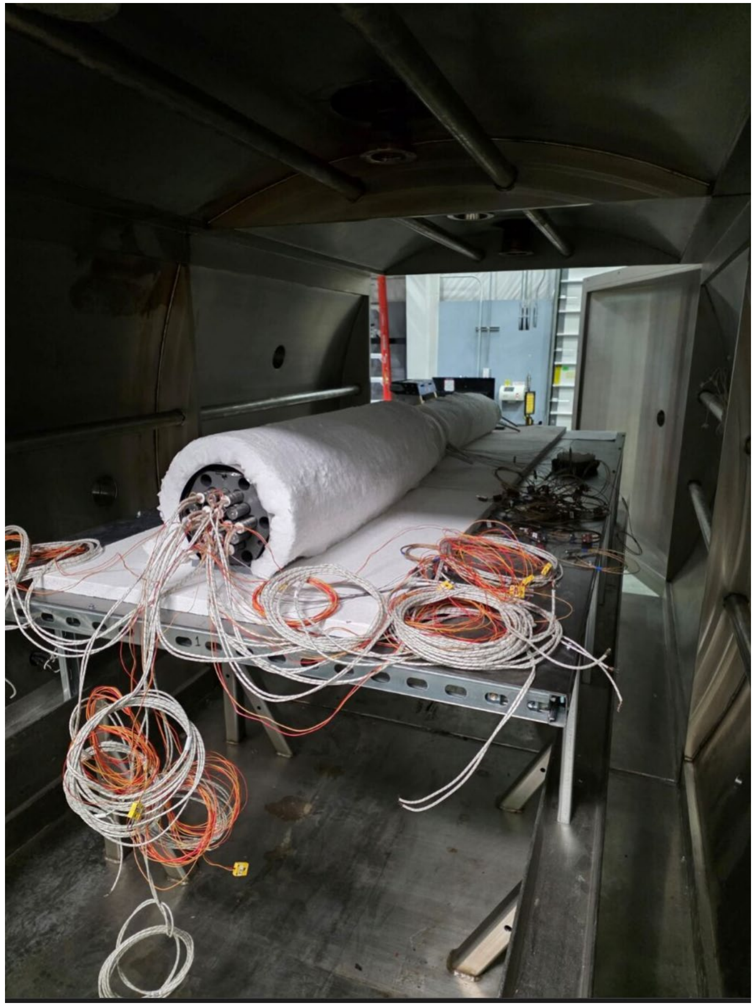


Graphite Block with SS MLI

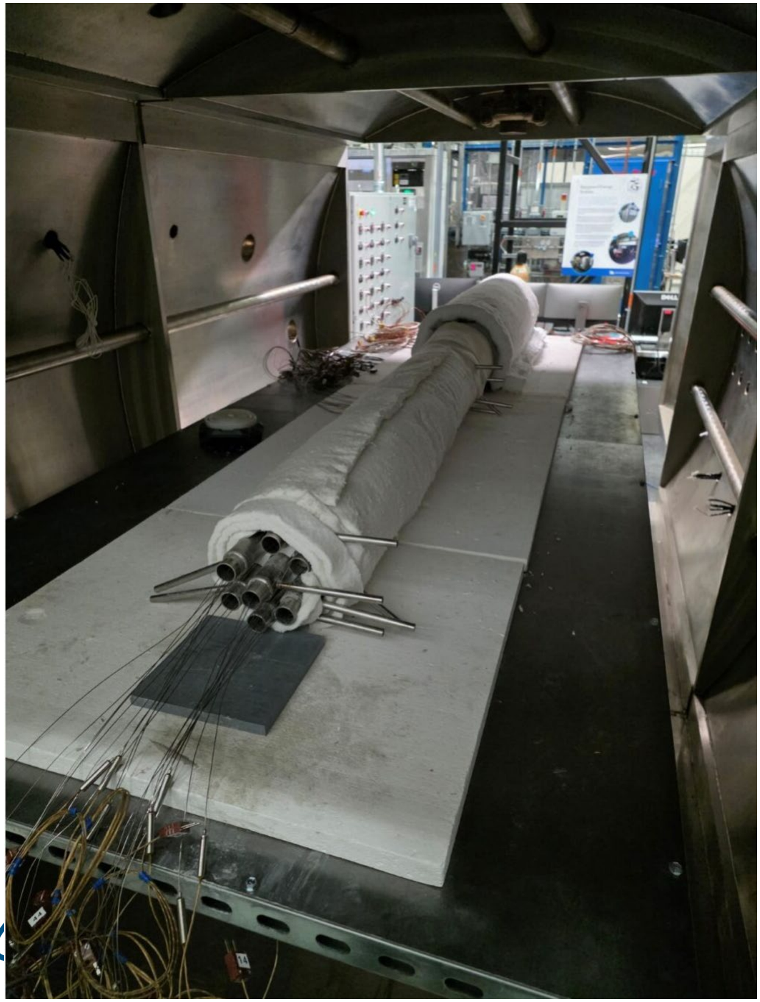
Heat Pipes

Heat Exchangers

Heated Side

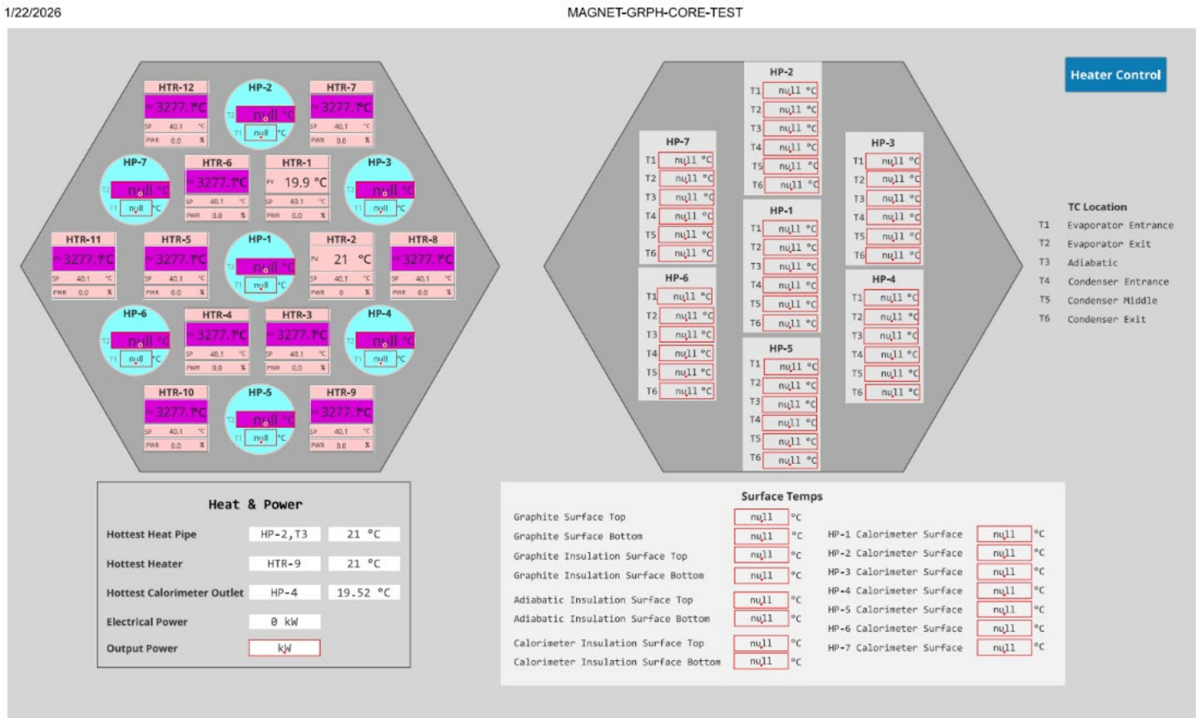


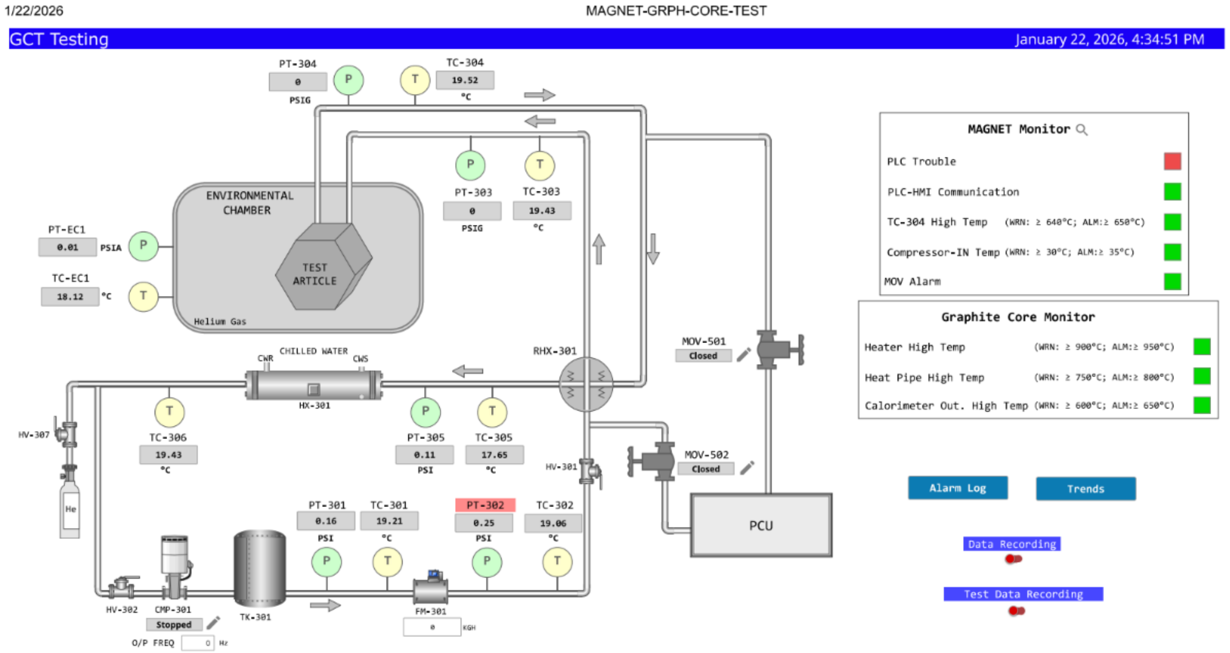
Cooled Side



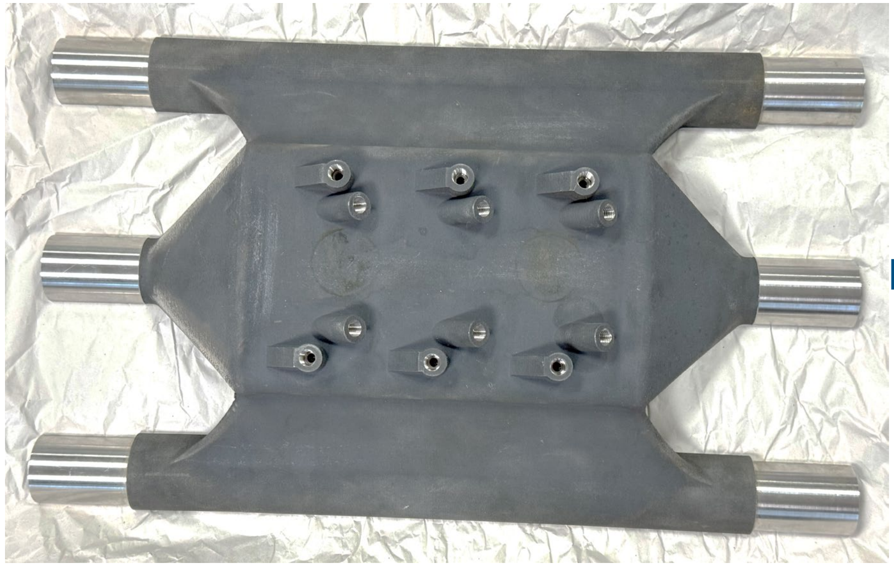
LANL Graphite Test Article HMI

- Developed heater controls for the new Cartridge Heater Panel (with 12 heater controllers).
- Programmed in Opto controller to monitor and control data for about 125+ LANL IO tags.
- Developed HMI screens for LANL experiment (7+ screens, with specific color coding for trends).
- Developed an HMI display header with 9+ calculations.
- Store all LANL IO to the database

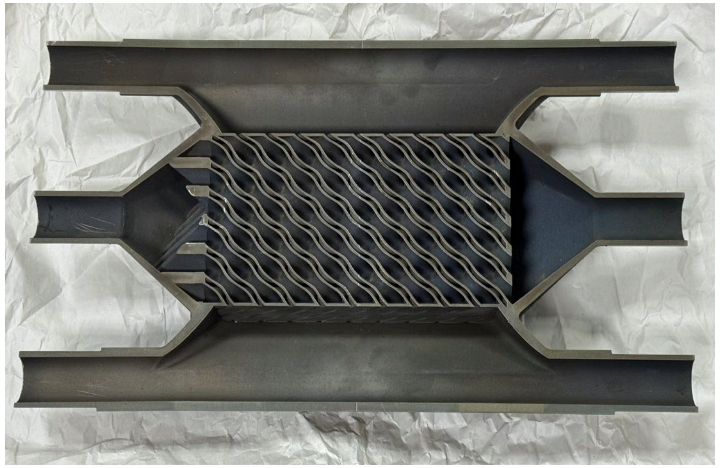




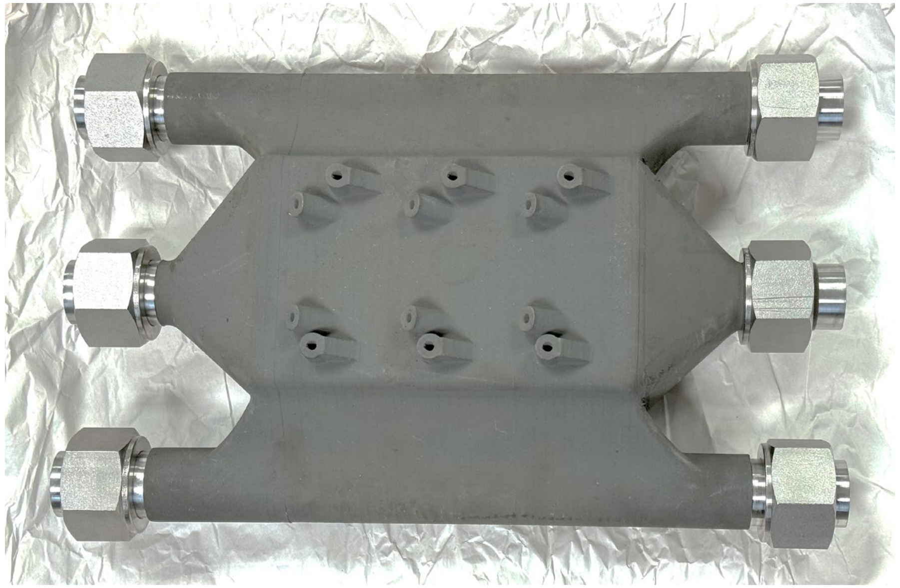
TPMS Heat Exchanger (HX)



Original HX Thermowells Drilled Through Domain Boundary



Original HX Internals



New HX With No Thermowells

- Triply Periodic Minimal Surface, 3-D Printed HX
- Test and evaluate HX performance
- First test will evaluate overall performance (flow rate, pressure drop, inlet and outlet temperatures)
- Second test will evaluate internal HX temperatures once thermowells are precision machined

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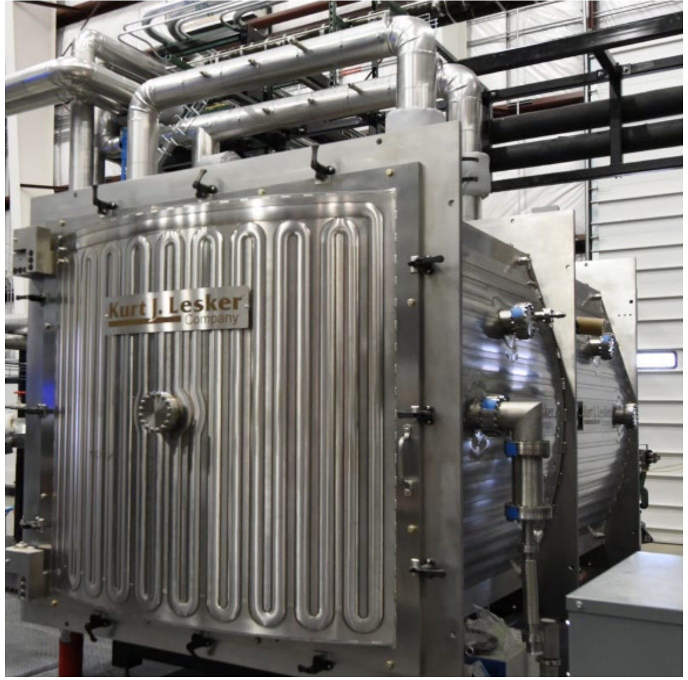
FY26 Milestones

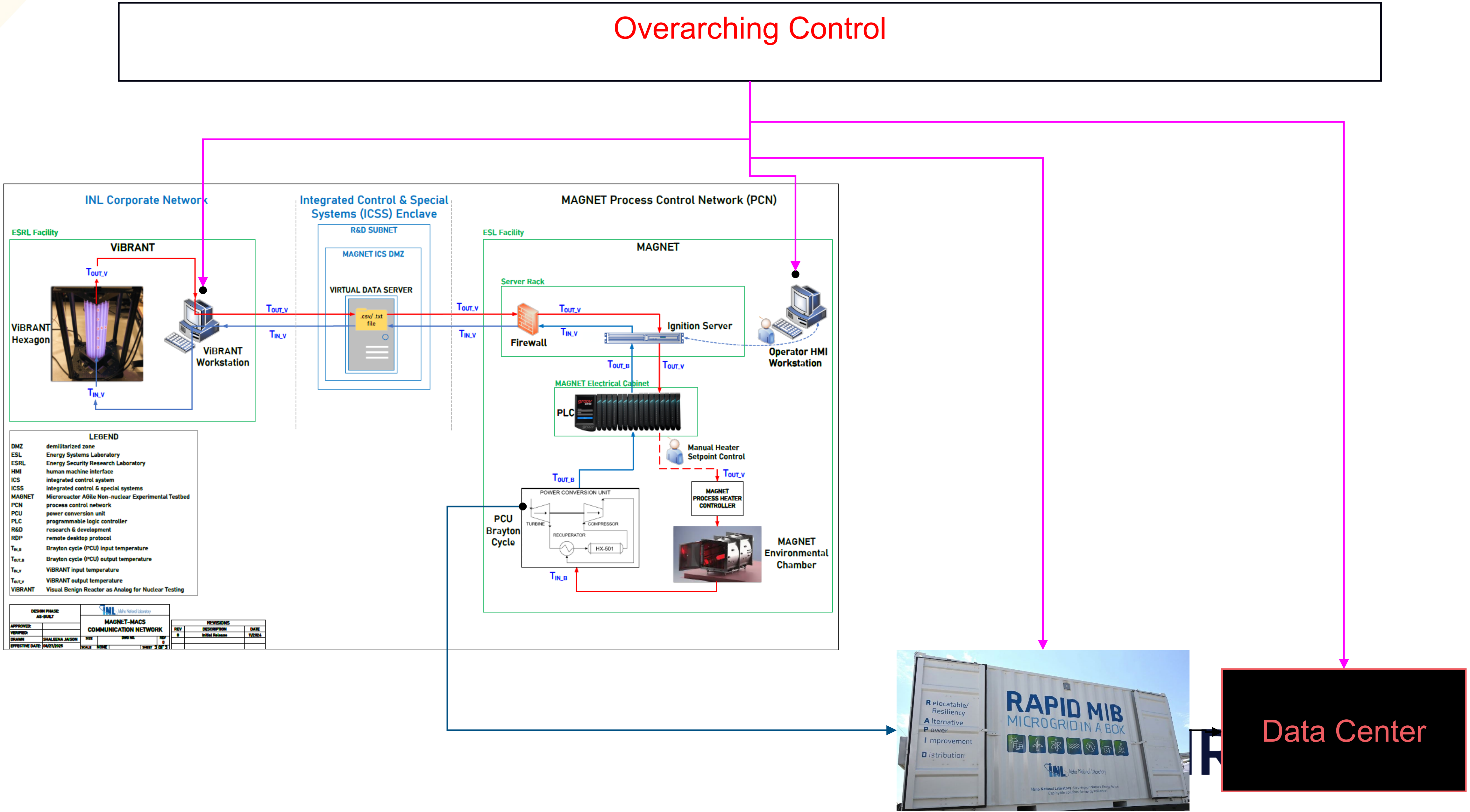
Milestone Description	Estimated Completion Date
Complete Performance Testing of Electrically Heated, Graphite Core Assembly	3/01/26
Complete PCU Shakedown Testing	3/31/2026
Perform TPMS HX Testing	3/26/2026
Prepare Optimized TPMS HX Design	5/28/2026
Validate Communications and Power Connections Between MACS, MAGNET, and MIB.	6/4/2026
Demonstrate Power Production With Integrated MAGNET PCU, Microgrid, and Mobile Data Center.	8/27/2026

MAGNET, MACS, and MIB Demonstrations

- Demonstrate integrated operation of Microreactor Automated Control System (MACS), MAGNET, and Microgrid in a Box (MIB) to power a mobile data center
- Work to enable previously “air-gapped” controls system access to INL network while maintaining safety features
- Intermediate milestone to establish and validate communications between MAGNET and MACS and between MAGNET and MIB.
- Perform integrated test in August
- Report on testing with data from MAGNET and the PCU



MAGNET, MACS, and MIB Demonstrations



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