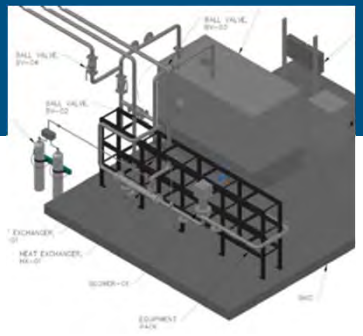
Demonstration & Support Area - Summary



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SPHERE

- The testing in SPHERE test bed provides:
  - Heat Pipe Thermal Performance
  - Startup and Shutdown Behavior
- Bi-Monthly Experimental Group Meeting to discuss ongoing activities, technical challenges if any
- Ongoing Collaboration with DOE-NEAMS to support verification and validation effort

Activity	Status	Date
Complete shakedown testing to demonstrate operability of the in operando heat pipe characterization system	In Progress: On Schedule	9/29/2023
Compile preliminary design needs for imaging system	Complete	11/7/2022
Complete Design and Instrumentation Needs for in operando heat pipe characterization	In Progress: On Schedule	4/27/2023
Complete Sockeye modeling of variable conductance heat pipe	In Progress: On-Schedule	8/30/2023

MAGNET

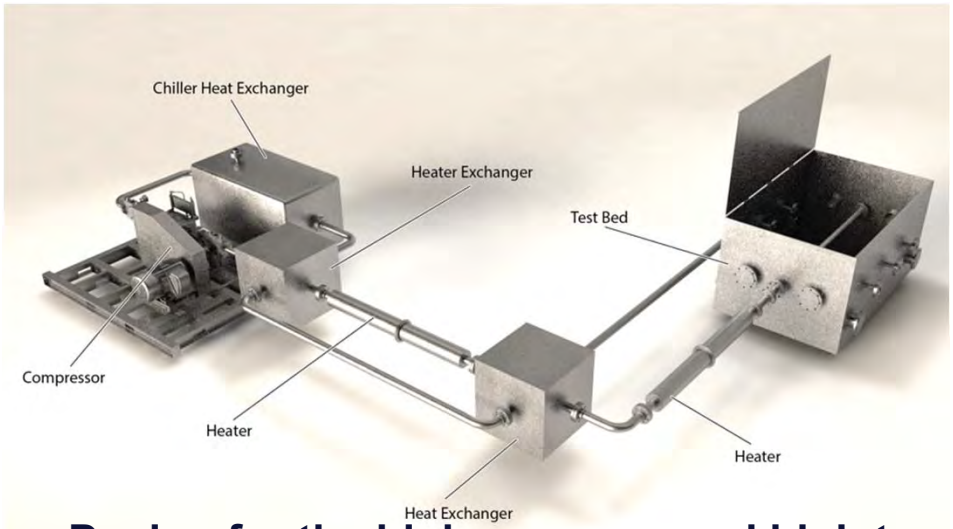
- Successfully tested proprietary HX design for commercial microreactor developer
- Mezzanine design is complete
- E37 test article installation and testing (scheduled for mid year)
- Working closely with DOE-IES to support integration energy studies

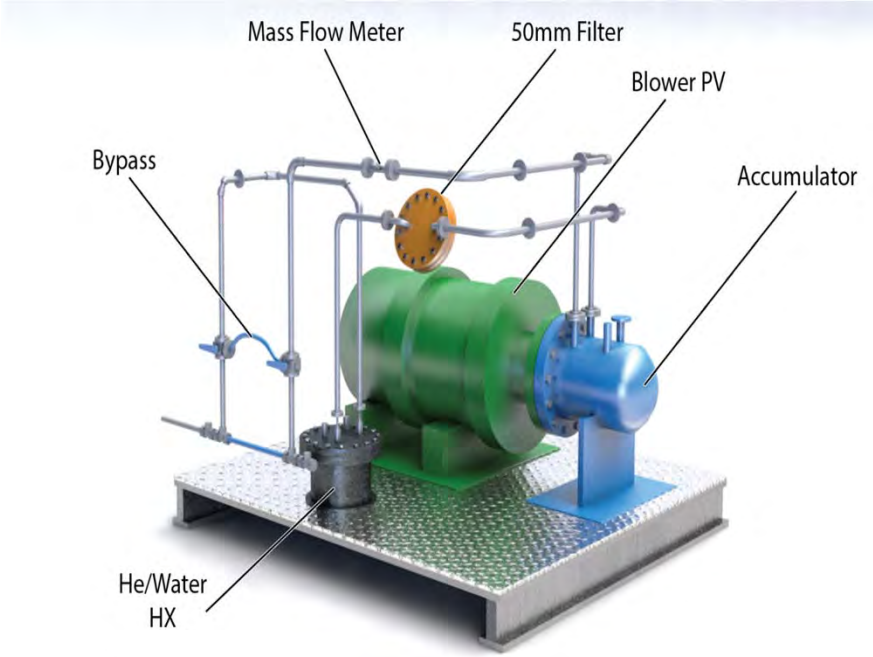
Activity	Status	Date
Formal Test Plan for e37 test article	Complete	Jan 2023
PCU Integration Design Package (specification and drawings)	In Progress	March/April 2023
Complete installation of e37 test article	In Progress	July 2023
Complete construction of MAGNET access mezzanine	In Progress	July 2023
Demonstrate system operation with commercial PLC	In Progress	September 2023

MRP Microreactor Program

HElium Component Testing Out-of-pile Research Facility

Operating Conditions	
Pressure	4 - 8MPa
Temperature	Up to 800 C
Mass Flow	0.01 – 0.15 kg/s
Reynold's Number Range	12800 - 412560





Not To Scale

Ongoing Design for the high pressure and high temperature test loop

MRP Microreactor Program

HECTOR

Activity	Status	Date
Complete preliminary design to achieve 4 MPa and 8 MPa at 800 deg C to support gas cooled microreactor concepts and component testing	In Progress: On Schedule	3/15/2023
Complete final design to achieve 4 MPa and 8 MPa at 800 deg C to support gas cooled microreactor concepts and component testing	In Progress	5/29/2023
Establish engineering contract for construction of high pressure and high temperature test bed	-	7/10/2023
Complete INL Engineering Job process and laboratory work control documents to enable procurement of the high pressure and temperature test bed	-	9/29/2023

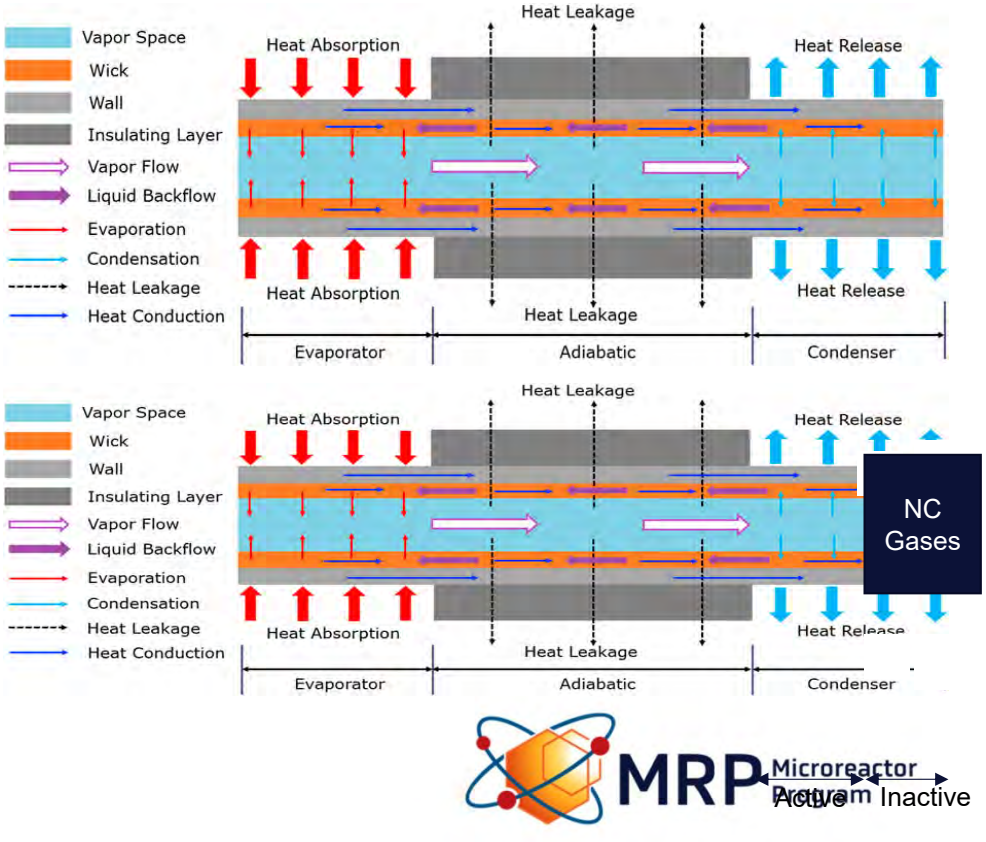
Modeling non-condensable gases (NCGs) in heat pipes

- The effective thermal conductivity model in Sockeye uses adapted thermophysical parameters for each region

	ρ	c_p	k
Vapor Space	$\rho_v(p_{sat}, T)$	$c_{p,v}(p_{sat}, T)$	$k_{core}(T)$
Wick	$\rho_l(p_{sat}, T)$	$c_{p,l}(p_{sat}, T)$	$k_l(p_{sat}, T)$
Wall	$\rho_{wall}(T)$	$c_{p,wall}(T)$	$k_{wall}(T)$

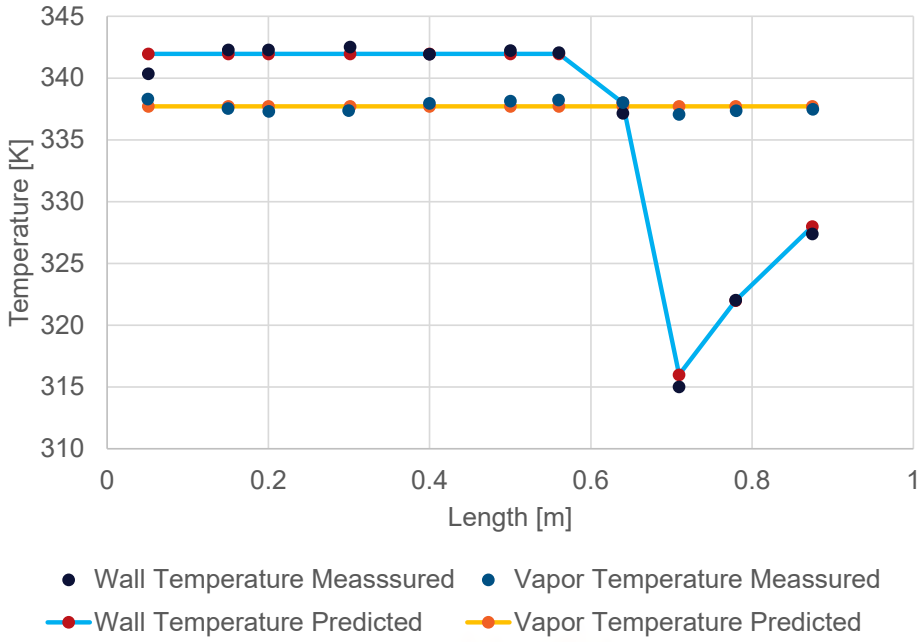
- Non-condensable gases shorten the active condenser length and increase the pressure in the heat pipe ($p_{eq} = p_{sat} + p_{nc}$). The modified

	ρ	c_p	k
Vapor Space	$\rho_v(p_{eq}, T)$	$c_{p,v}(p_{eq}, T)$	$k_{core}(T)$ Only for active length
Wick	$\rho_l(p_{eq}, T)$	$c_{p,l}(p_{eq}, T)$	$k_l(p_{eq}, T)$
Wall	$\rho_{wall}(T)$	$c_{p,wall}(T)$	$k_{wall}(T)$



Validation of effective thermal conductivity model without NCGs

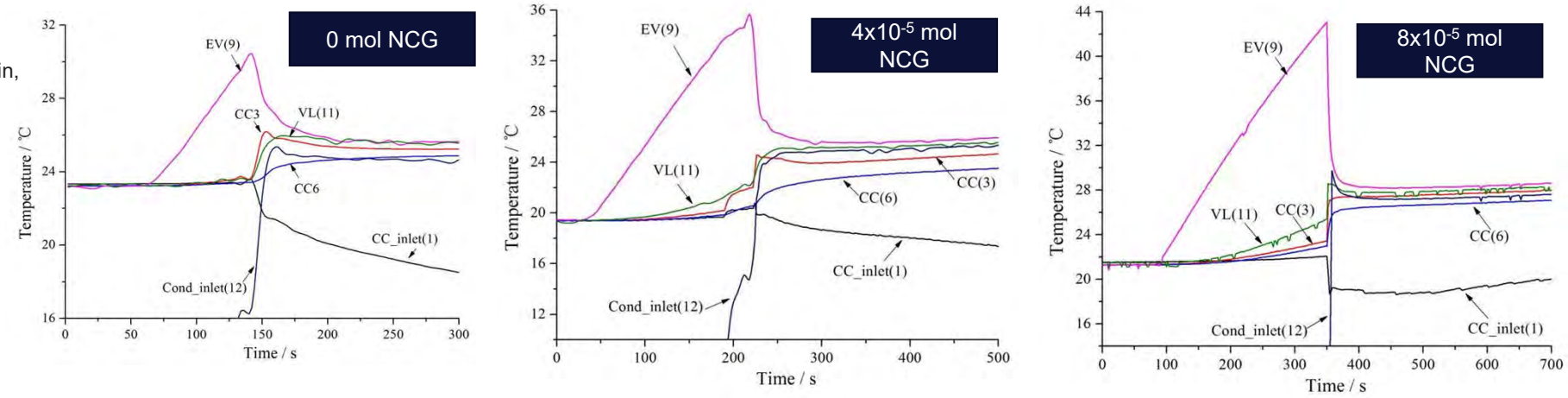
- A new validation data point has been added to the validation base in Sockeye
- The experiment performed by Huang et al. consists of a copper-water heat pipe with a long condenser
- Since the condenser will be the main component affected by NCGs, this preliminary validation exercise tests the capability of the effective thermal conductivity model to appropriately model phenomena at the condenser
- Good agreement is obtained between the experiment and the model



Huang, L., El-Genk, M. S., and Tournier, J. M. (1993). Transient Performance of an Inclined Water Heat Pipe with a Screen Wick[J]. *ASME-PUBLICATIONS-HTD* 236, 87.

Experiment selected to test the effective heat conduction model with NCGs

He, J., Miao, J., Bai, L., Lin, G., Zhang, H., & Wen, D. (2017). Effect of non-condensable gas on the startup of a loop heat pipe. *Applied Thermal Engineering*, *111*, 1507-1516.



- He et al. experiment selected for testing the model, which uses an ammonia-stainless steel pipe with Nitrogen as NCG
- Key effects to capture in the model:
  - Larger operating temperature of the heat pipe due to pressurization
  - Steeper slope in condenser due to reduced active length
  - Steeper slope in the evaporator due to pipe pressurization
- Simulations are currently being performed (ongoing effort)

Main Conclusions

- Working closely with other DOE Programs to leverage and support joint efforts
- Regular interaction with industry through programs such as NRIC (ARDP funded projects)
- Interaction with Academia through DOE-NEUP program
- Bi-Monthly Meetings with PI's of NEUP's who are involved in experimental work
- Successful demonstration are needed to gain utility, regulator, and public confidence.

Path Forward

SPHERE

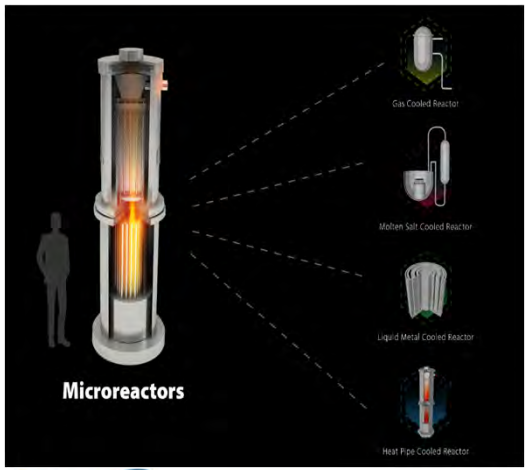
- Demonstrate operability of the in-operando heat pipe characterization system
- Heat Pipe performance - supporting industry needs
- V&V support for Sockeye

MAGNET

- Installation and Testing of e37 Heat Pipe Test Article

HECTOR

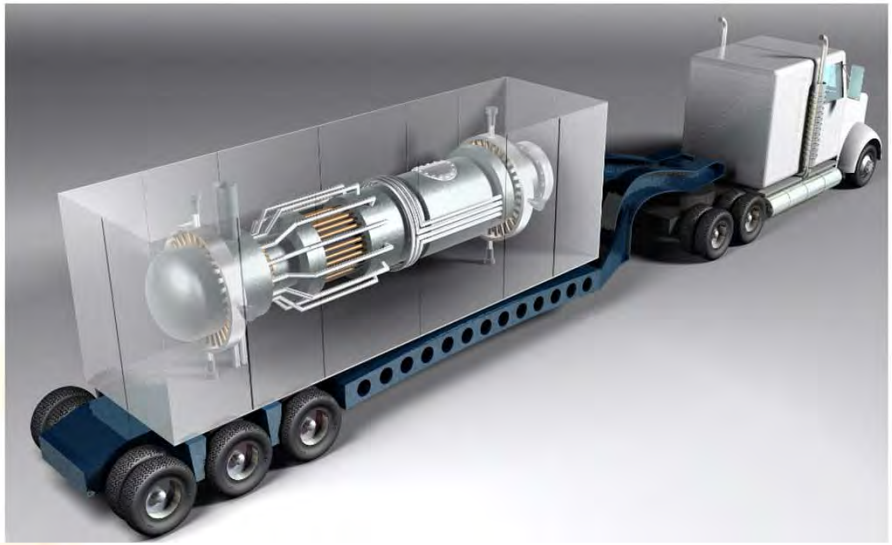
- Complete design for the high pressure and high temperature He loop

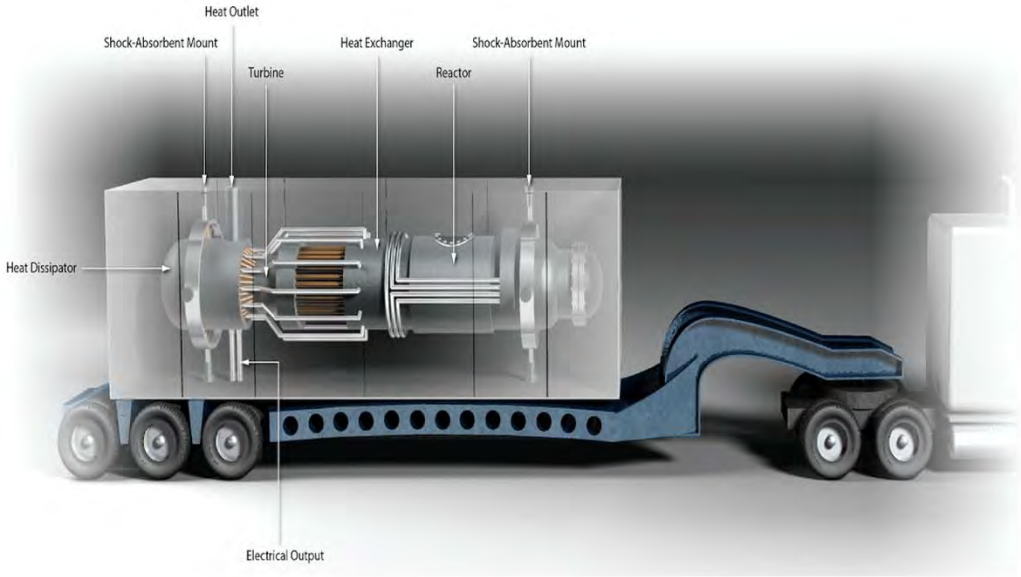


MRP Microreactor Program

Thank You..!

MRP Microreactor Program





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Credit & Acknowledgement

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OAK RIDGE National Laboratory

Argonne NATIONAL LABORATORY


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