



# **DOE Microreactor Program**

# Instrumentation, Sensors and Controls for MAGNET

**Technology Maturation Panel** 

GAIN-EPRI-NEI Microreactor Program Workshop August 18, 2020 Troy Unruh (Presenter) Idaho National Laboratory

David Mascarenas Los Alamos National Laboratory

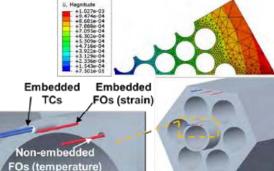
Chris Petrie, Pradeep Ramuhalli, Dianne Ezell Oak Ridge National Laboratory

# Background – Instrumentation, Sensor and Controls

 Scope overview – Instrumentation is a unique challenge in that technology must be placed in advance to "see" what happens inside a microreactor throughout its life with little or no access.

Focus areas include:

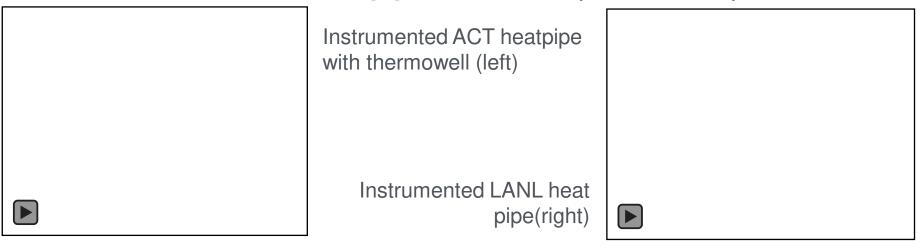
- Nuclear Energy Enabling Technologies Advanced Sensors and Instrumentation (NEET ASI) program leveraged for demonstration of ASI-developed instrumentation in MAGNET (e.g. sensors for nonnuclear tests)
- 2. Sensors for structural health monitoring
- 3. Embedding sensors for performance
- 4. Autonomous sensing and control
- Alignment with program objectives
  - The research supports development of advanced technologies and concepts for next-generation microreactor applications and systems
  - Research and <u>deployment of infrastructure to support demonstration</u>



# Instrumentation for microreactor components -Initial focus on heatpipes



Received and scanned heat pipes from ACT (commercial) and LANL



• Distributed temperature sensor procurement and deployment (Thermocouple, Fiber, Ultrasonic)

, 4° 200	51.2.						
Inch Conversion 40.39	Drawing For S&L Dim	ensions Only	5.91	71.45	48.47 Indies Wire Length	Distributed	
	114 106	105	151	550	1231.20 mm field Wire Length 4.04 Ft Total Wire Length	Distributou	
QA MEAGURMENT AT S&L	(.5° (.18° /8.25*	4.18	/			thermeequale drewing	
FINISHED LENGTHEA Insured 18-8	75" 24595"	19.75	(15' 4'	DEC OVERALL	( LENDYH)	thermocouple drawing	
FINAL NEEDED LENGTH MIN.	457.2 457.2	457.2	711.2	2585	A A		
Reservator 5119 PT1 Docentida 4019						(left)	
Course-It 16.14 MGO		PT3 F	T4		(Drawing Take N	17.29	
Swage Only Tip No Wire	PT2				Garantic It Each Wire/H	16.64 4.64 18.54	
200mm 200mm			End 0	2 Tube Extra	6" For Mile. Tutal West It	18.56	
•	•	•	•			Eibor optic tomporaturo	
Empty Tube 50.8001						Fiber optic temperature	
	N POINTS: 15-Pt2 PT2-PT3	PT3-PT4	Ph4 - End Of Tube	Extra 6" For Mfg.	EXTENSED WIRE 20%		
Expected Wire Elongation	4 4.31	4.35	4.725	4.7	LONGER THAN TUBE	sensor "wire wrap"	
IMPORTANT NOTE CUSTOMERS POINT	LOCATION DESCRIPTION MAY NOT	BE THE SAME AS THE	LC "PT NUMBER".				
PT3 - ALL DIMENSIONS ARE MEASURED FROM THIS FIRST JUNCTION DIMENSIONS ARE IN mm GA / LAB FINAL CHECK BY:						around simulated heat	
ILC WORK ORDER:	SALES OF	RDER:	_	GA IN PROCESS C	HEOKED BY JUM 722-2	around onnulatod noat	
CUSTOMER DRAWING SHL BY						pipe (right)	
TAG NO:							
RECORD POINT LOCATIONS AND LENGTHS AT S-L GA INSPECTION AND FINAL GA INSPECTION. UNDER STATUS AND AND FINAL GA INS							
L							



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#### Structural integrity monitoring for microreactor core block

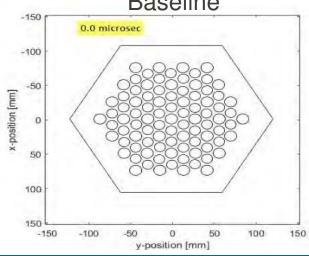


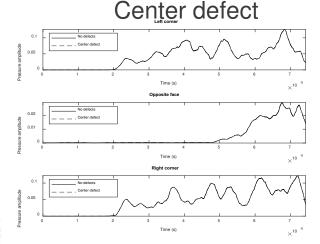
Contact: David Mascarenas, dmascarenas@lanl.gov

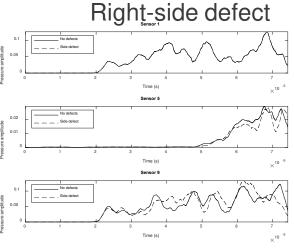
Determine viability of using commercial strain sensing technology for measuring the strain on the external surfaces of the core block at prototypic temperatures



Simulations to explore feasibility of ultrasonic techniques for identification of web defect locations in stainless steel, molybdenum, and graphite **Baseline** 

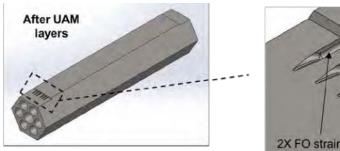


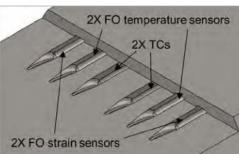


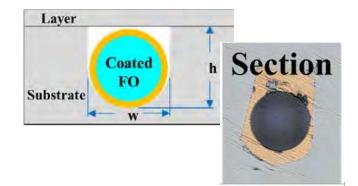


### Sensor embedding for cross-cutting microreactor applications

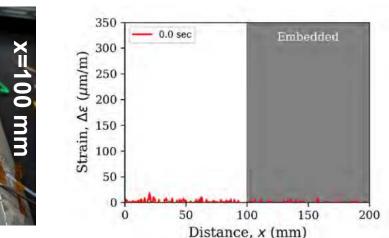
 Thermocouples and fiber optic temperature and strain sensors embedded into core block and simulated heat pipes

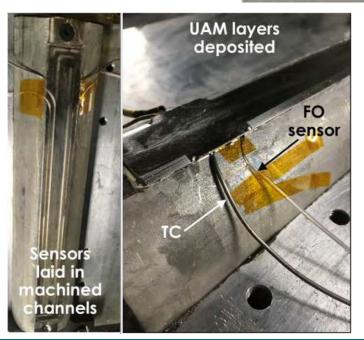






[1] C. M. Petrie et al., Smart Materials and Structures 28 (2019) 055012





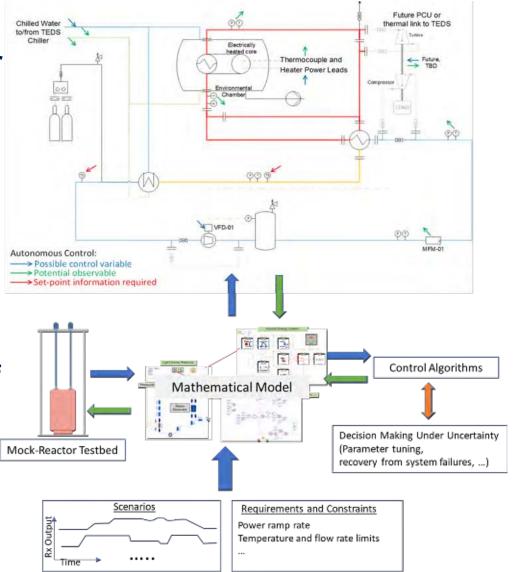


# Autonomous control for use in MAGNET



Contact: Pradeep Ramuhalli, ramuhallip@ornl.gov

- Infrastructure development for autonomous operation of MAGNET
- Instrumentation upgrades identified to enable autonomous operation
- Scenarios and requirements identified for demonstration of cross-cutting control and decision-making for autonomous operation



#### Future work plans and priorities: Instrumentation, Sensors and Controls

- Develop plan for testing internal and external sensors in MAGNET
  - Distributed temperature sensors (thermocouples, acoustics, fiber optics)
  - Dimensional measurement sensors (LVDTs)
  - Neutron flux sensors (fission chambers, SPNDs)
  - Structural health monitoring (contact, non-contact, embedded sensors)
  - Embedded sensors (various sensors)
- Perform structural health monitoring evaluations in MAGNET
- Embed sensors in prototypic geometries and perform comprehensive thermal testing
- Demonstrate control strategies for selected test article in MAGNET and submit control design for nuclear application testing in TREAT



MAGNET test chamber

# Clean. Reliable. Nuclear.