NRIC National Reactor Innovation Center

Laboratory for Operations and Testing in the United States (LOTUS)

NRIC Test Bed

Presenter: Jacob Rymer, NRIC Technical Program Manager

04/01/2025

Agenda

- Importance of the LOTUS Test Bed
- Location of LOTUS
- Test Bed Experiment Capabilities
- Test Bed Project Status
- Test Bed Project Next Steps
- Questions?

Importance of the LOTUS Test Bed

Innovation Acceleration:	• Promotes rapid prototyping and iteration.
Safety and Reliability:	• Designed to support Department of Energy (DOE) Requirements for nuclear experiments.
Cost Effectiveness:	• Shared infrastructure reduces the financial burden to developers.
Collaboration and Knowledge Sharing:	• Fosters interdisciplinary research and provides access the national laboratory subject matter experts.
Regulatory Support:	• Experiments provide valuable data for safety standards, guidelines, and the licensing process.
National Security and Energy Independence:	• Promotes domestic energy abundance and technology advancement which reduces foreign energy reliance and enhances nuclear security.

Location of LOTUS

Location: INL Materials and Fuels Complex (MFC); Zero Power Physics Reactor (ZPPR) Facility.

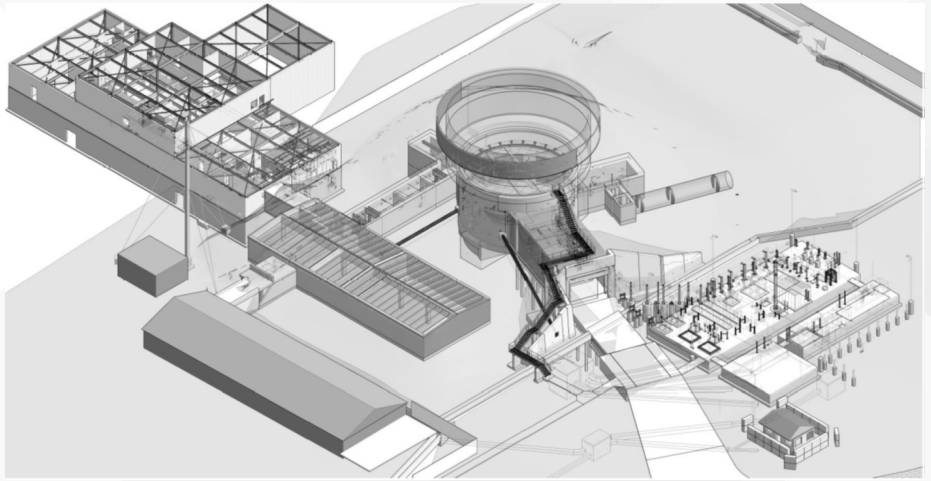
Meeting the Needs: Provides infrastructure to support DOE Authorized experiments requiring a Hazards Category 2 facility and fuel designs requiring an elevated security posture.

NRIC-LOTUS Test Bed

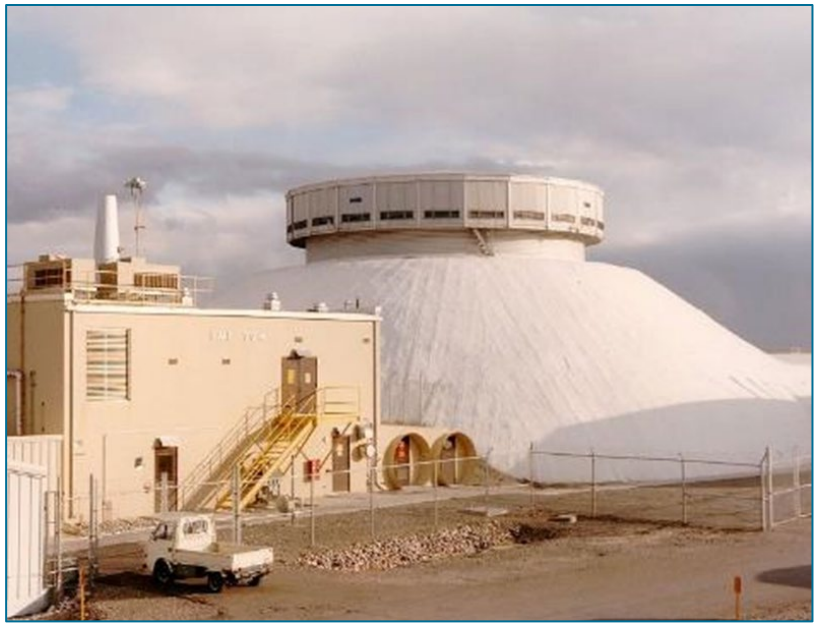
Test Bed Experiment Capabilities

Advanced Reactor Experiments:

- Heat Removal Systems:
  - Cell Heat Removal – (2) HVAC systems; 50kW$_{th}$ per unit.
  - Reactor Heat Removal – Min: 25kW$_{th}$; Max: 500kW$_{th}$
    - System designed only, not currently planned for installation.
- Power Systems:
  - In Cell:
    - Normal Power Supply – 480VAC, 450A, 3 Phase.
    - Auxiliary Power Supply – 208VAC, 160A (continuous).
    - Standby Power Supply Available.
  - In Control Room:
    - Normal Power Supply - <18 kW, 208 VAC, 3 Phase.
  - Emergency Power Supply via Safety Significant Battery System.



Test Bed Experiment Capabilities



- Gas Systems:
  - Argon – 2 scfm, 90 psig (steady state); 15 scfm, 90 psig (1 hr max).
  - Compressed Air – 3 scfm, 100 psig.
- Cell Information:
  - Equipment Tunnel Access – 13 ft x 13 ft.
  - Radiological Confinement.
  - 30 ft usable diameter, 16 ft 11in height to bottom of crane hook.
    - Recessed pit area inside cell.
  - 5 Ton Polar Crane.
- Yard:
  - Access to Equipment Tunnel and laydown area.
  - Equipment Pads and Cell Ventilation Stack.
  - Reinforced Safety Class equipment pad.

Test Bed Project Status

- Capital Asset Line-Item Project: CD-1 Approved – June 2023
- Final Design: Complete – September 2024
- Preliminary Design Safety Analysis (PDSA): Submitted for Review/Approval – September 2024
- CD-3A, Long Lead Procurement: CD-3A Approved – March 2025
- Solicited Request for Proposal (RFP) for Construction – December 2024.
  - Market conditions continue to present a challenge.
  - RFP issued to 10 potential contractors; only 2 participated in the mandatory pre-proposal conference.
  - Bids (Construction and Long Lead Procurement) will be used to inform Performance Baseline cost, schedule, and risk profile.

Test Bed Project Next Steps

- CD-2/3B Submission for Project Management Executive – Q1 FY 2026
  - CD-3A Approval – March 2025 (Assumed Dec. 2024) – Allows procurement of critical long lead items.
  - Bidders requested additional time based on supplier/sub-tier market and complexity of certain construction elements (e.g., excavation and shoring); extension granted to retain bidders and maintain competition in bid process).
- Construction Finish Forecast – early Q2 FY2028 (to be refined based on bids)
- Operational Readiness Forecast – Q1 FY2029
- Project continues to pursue opportunities to accelerate schedule

Questions?

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04/01/2025

Don Wood, Ph.D.
Senior Technical Advisor, MCRE

The Molten Chloride Reactor Experiment (MCRE)

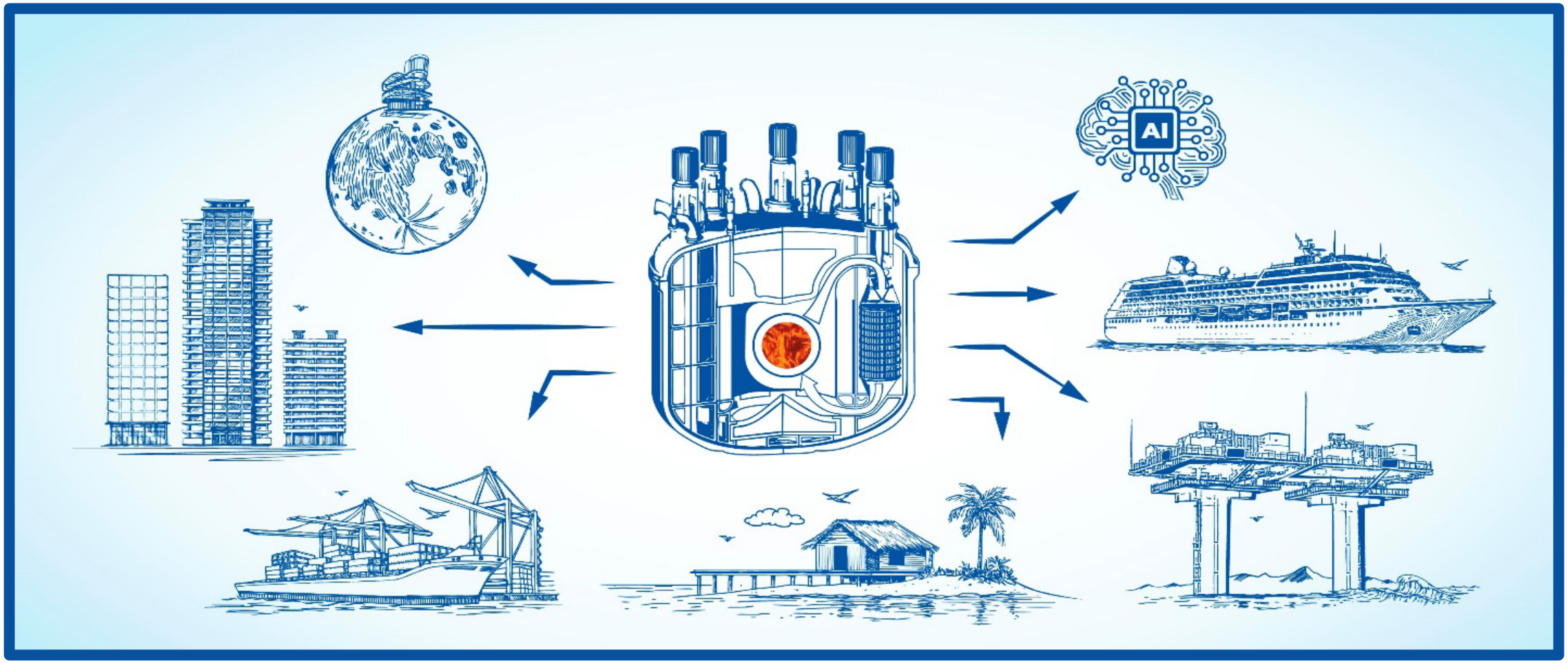
NRIC Program Review 2025

Battelle Energy Alliance manages INL for the
U.S. Department of Energy's Office of Nuclear Energy

Idaho National Laboratory

MIS-25-83405

MCRE - Abundant Energy for the Future



Molten Salt Reactor Innovation

MCRE

- First ever criticality of a chloride salt reactor
- Groundbreaking molten salt chemistry research
- Pioneering molten salt fuel synthesis
- Rigorous systems engineering
- Designed for removability from LOTUS
- Unprecedented commercial partner collaboration
- Technologically suited for maritime applications

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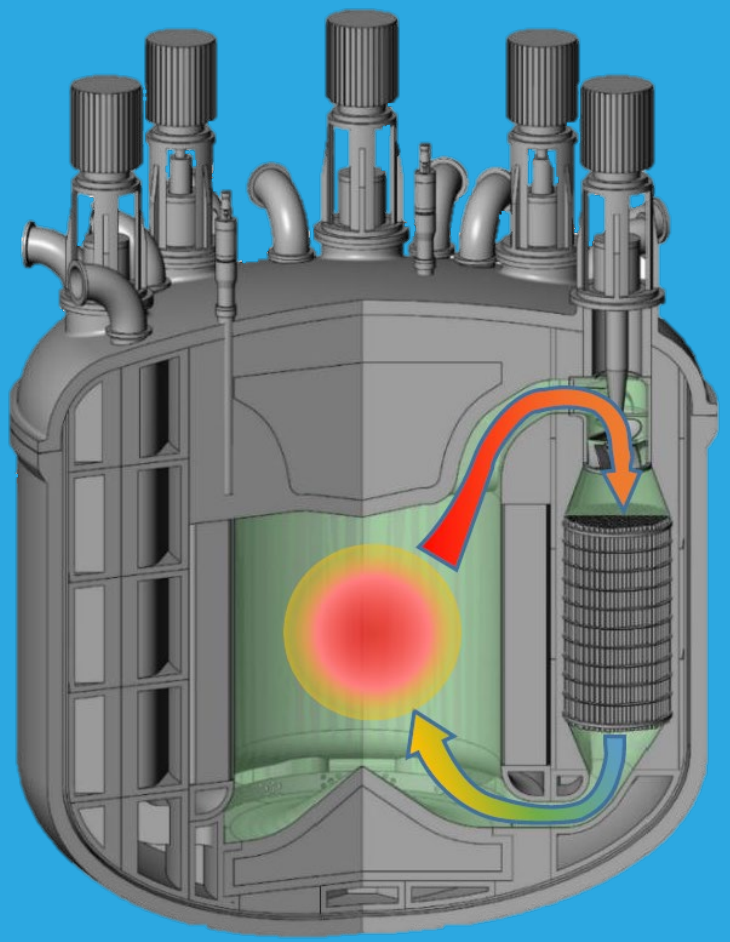
Molten Chloride Fast Reactor (MCFR)

Liquid Fuel Salt

- High operating temperature improves power conversion efficiency and enables valuable industrial applications
- Low pressure system removes need for thick, expensive vessel walls
- Flowing fuel eliminates need for refueling outages and provides load following reactivity control

Fast Neutron Spectrum

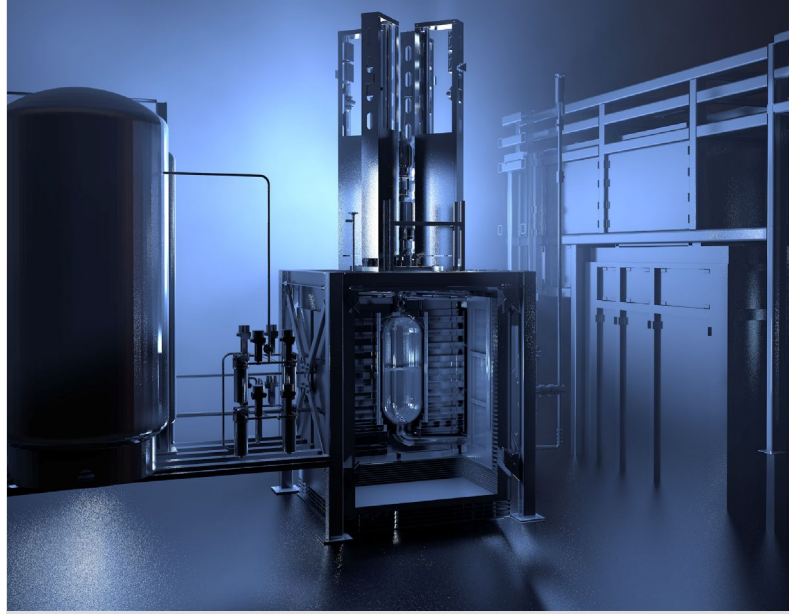
- Core can tolerate fission products and achieve high burnup
- Reactor breeds new fuel and utilizes that fuel directly without need for a reprocessing plant
- Destroys longest-lived nuclear waste isotopes, reducing amount of waste and shortening the hazardous lifetime



MCRE lays the foundation for commercial MCFR deployment

Molten Chloride Reactor Experiment

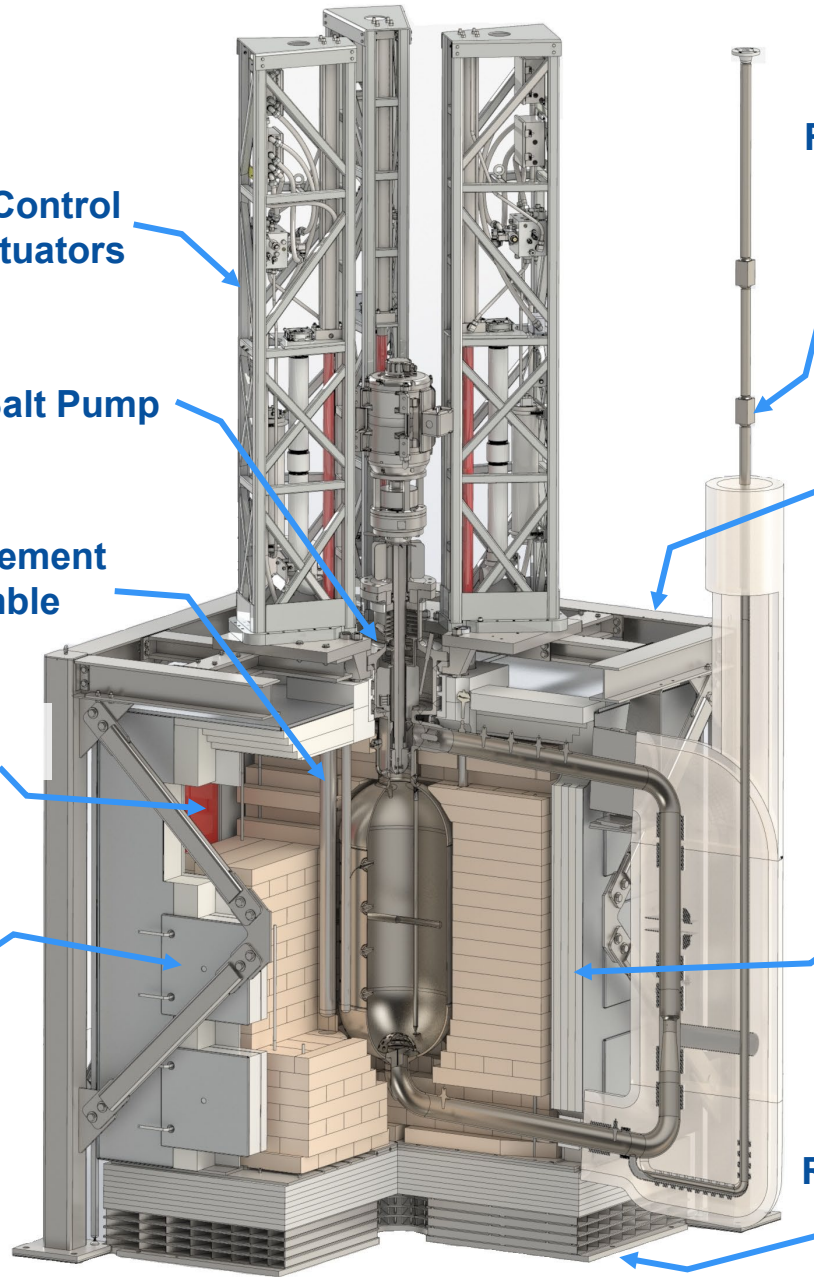
- Advanced Reactor Demonstration (ARD) Risk Reduction Award
- Collaboration led by Southern Company
- TerraPower responsible for reactor design and fabrication
- INL responsible for fuel salt production, reactor installation, operation, and post-operations decommissioning
- INL host site, NRIC-LOTUS reactor test bed
- Critical operation in 2029



Objectives

1. **Safely achieve criticality**
2. **Determine reactor physics and kinetic parameters to reduce uncertainty and gather data**
3. **Demonstrate fuel handling strategy for chloride fuel salt**
4. **Initiate industrial supply chain for molten salt components**
5. **Collect data for licensing framework**

Integrated Effects Test (IET) commissioning is nearly complete at TerraPower's laboratory in Washington

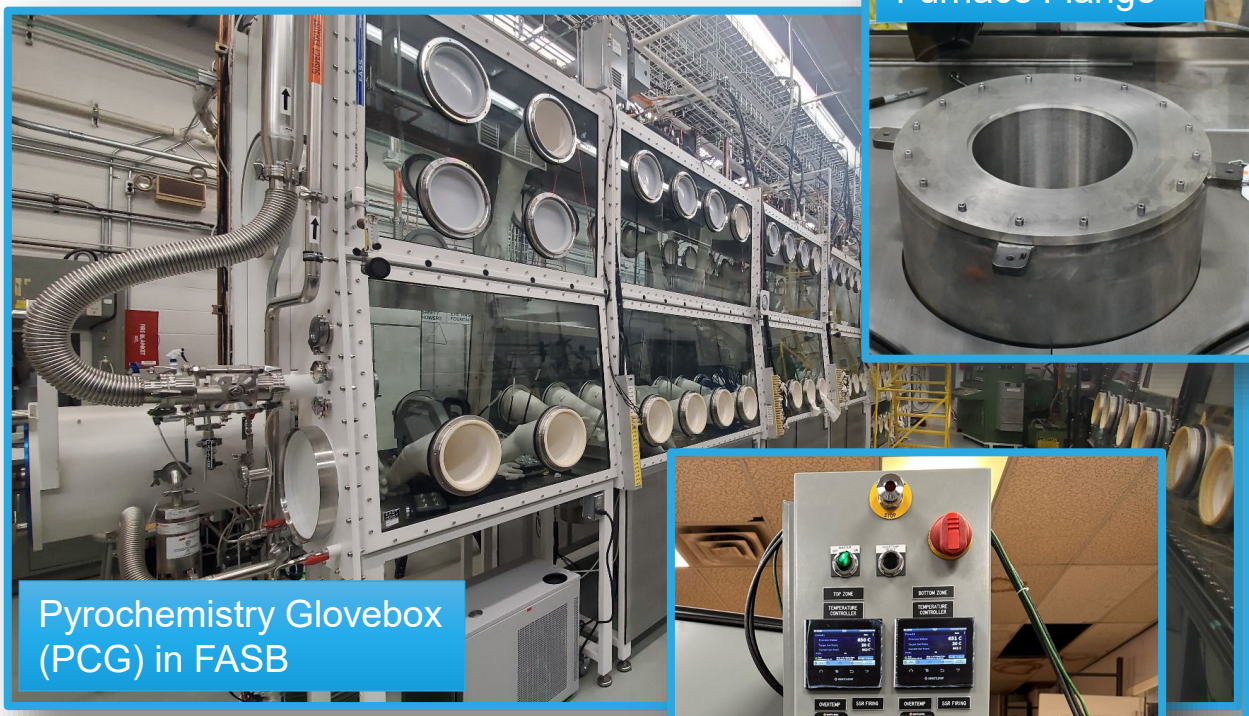


MCRE Systems – RCS Group

Group	System ID	Name
MCRE Plant	PLT	Molten Chloride Reactor Experiment
	OPS	Reactor Experiment Operations
Reactor	RCS	Reactor Core System
	RFL	Reflector System
	RXE	Reactor Enclosure System
	RSS	Reactor Support System
	CHT	Core Heating System
Pump	PUMP	Fuel Salt Pump
Fuel	FHS	Fuel Handling System
	CGS	Cover Gas System
	FUEL	Fuel Salt
Reactivity Control	KCS	Reactivity Control System
Auxiliary	ECS	Environment Cooling System
	ACS	Auxiliary Cooling System
	SHD	Radiation Shielding System
NIC&EL	NIS	Nuclear Instrumentation System
	RPS	Reactor Protection System
	IC	Instrumentation & Controls System
	EL	Electrical System

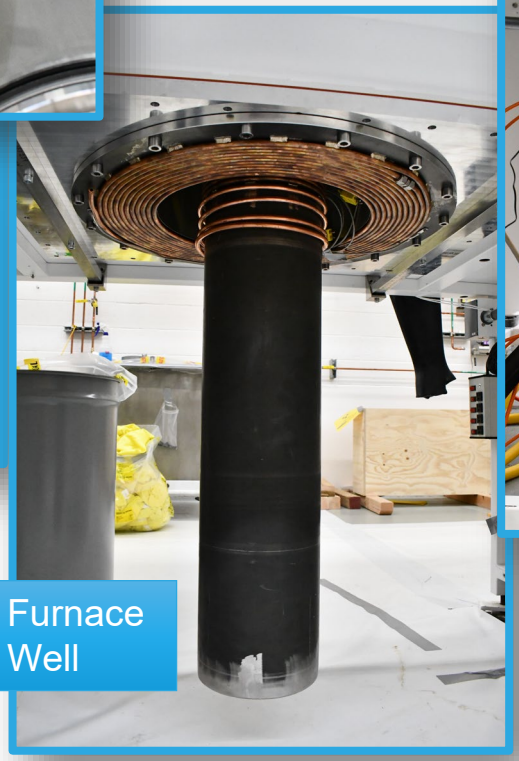
INL MCRE team has developed an elegant process for fuel salt synthesis

The first MCRE fuel synthesis furnace is now installed in the Pyrochemistry glovebox at MFC in the Fuels and Applied Sciences Building (FASB)


Pyrochemistry Glovebox (PCG) in FASB

Furnace Flange

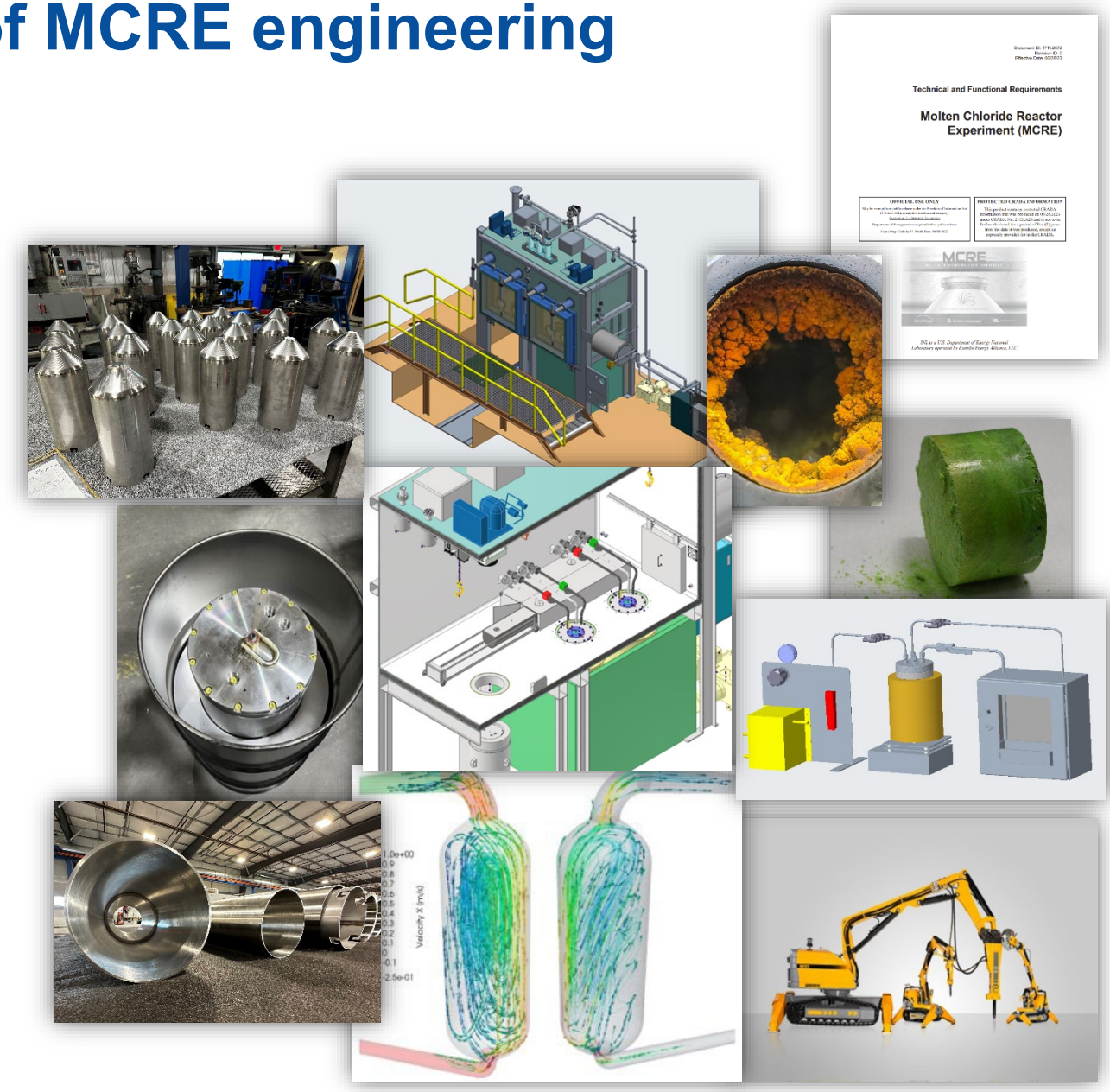

Furnace Controller


Furnace Well


Fuel Synthesis Furnace

INL is involved in all aspects of MCRE engineering and operations

- Design Authority for MCRE design
- DOE Authorization – Approved Conceptual Safety Design Report (CSDR), working on Preliminary Design Safety Analysis (PDSA)
- Developed Reactor Demonstration System Design Requirements Document
  - Summarizes all industry, DOE, and INL requirements (TFR-2572)
- Criticality Safety and Nuclear Safety
  - Experimental campaign to study salt behavior during off normal conditions
- Confirmatory Reactor Analysis (CRA)
- Design of FSSL and MCRE-LOTUS interfaces
  - Fuel Handling Glovebox (FHG), Fuel Salt Containers (FSC), Salt Extraction Unloading and Storage System (SEUSS)
- Development of chloride salt quantitative analytical techniques for trace light element analysis
- Responsible for installation, operations, defueling, decommissioning, post irradiation examination (PIE), and equipment removal and disposition (ERD)



MCRE Mockup hardware arriving at TerraPower Everett Lab. Construction to complete by September 2025. Full-scale, electrically heated, flush salt only (no uranium)


Flush Tank

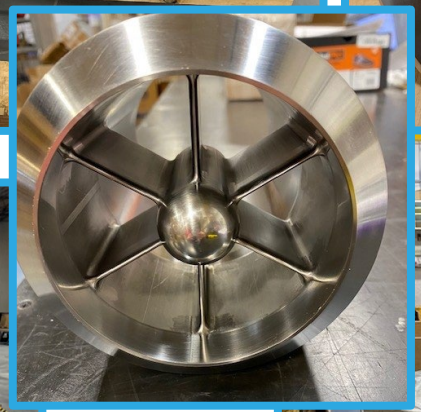
RXE upper and lower loop


Fuel tank shell


30”x6”x3” MgO reflector bricks

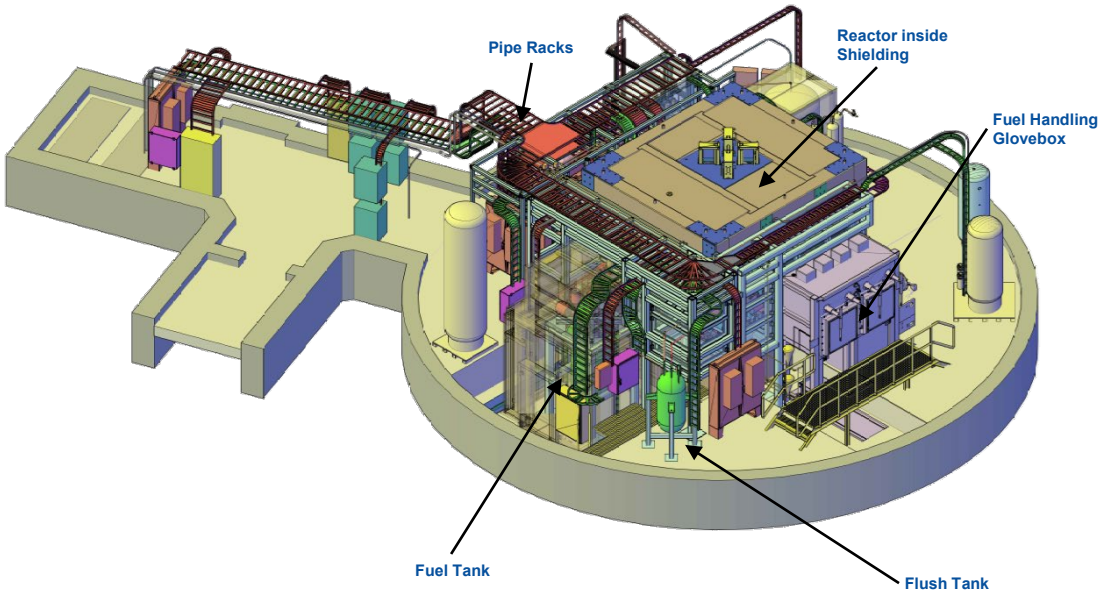

RXE 625 vessel heads


Mockup pit



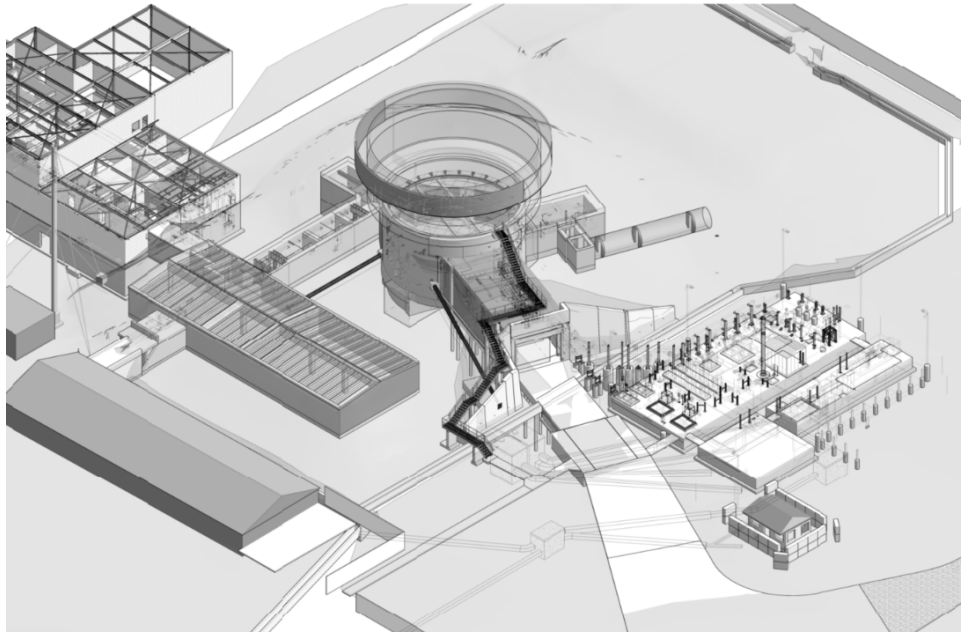

Fuel Pump

Laboratory for Operational Testing in the United States (LOTUS) Testbed Overview



MCRE shown with shielding in LOTUS cell

LOTUS will be built in the Zero Power Physics Reactor (ZPPR) mound



- LOTUS reactor test bed is at final (90%) design
- Construction scheduled to begin end of FY25
- Capable of supporting fuels that require enhanced security
- Up to 500kWth heat rejection

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Questions?

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