Molten Salt Reactor PROGRAM

Salt Loop and Capability for Testing Sensors and Off Gas Components

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Oak Ridge National Laboratory

MSR Campaign Annual Review, April 21-23, 2026, SNL

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FY26 PICS milestones (upcoming M3)

Milestone Number	Description	Date
M3AT-26OR0702021	Initiate Liquid Salt Test Loop refurbishment with replacement of the old pump and pump tank	Due 9-30-2026

What are we trying to do?

1. **Re-establish foundational US infrastructure** (*facilities and personnel expertise)* to enable innovation and advance technologies for MSR applications
   - The facilities are the largest and most capable within DOE complex
   - Prepare the next generation workforce with hands-on experience on engineering-scale salt facilities.
   - Spur the supply chain and act as first mover on first-of-a-kind needs
2. **Accelerate MSR deployment** by bridging the gap between research and commercial deployment
   - De-risk sensors to monitor species transport and salt chemistry in situ.
   - Conduct component testing in prototypic environments, *beyond bench scale*, to understand practical operations and to optimize reliability, risks, and costs
   - Open to universities, laboratories, and component developers that don't have similar capability
3. **Enhance confidence in salt community** (MSR developers, regulators, component developers, and other invested entities)
   - Serve as an open test facility and trusted 3rd party with published results
   - Establish knowledgebase for code validation, component/system performance, and demonstrated successes

Reminder of Recent Journey

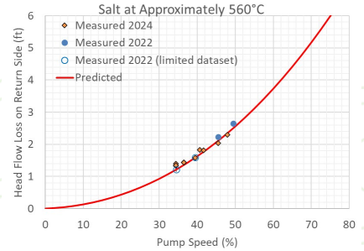
FY26 LSTL refurbishment

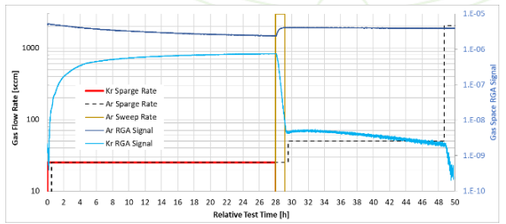
FY25 Operation of FASTR (*separate papers*)
- 6 aerosol tests from pump tank
- H_2, D_2, Kr, Xe, injection tests with Raman probe (PNNL), LIBS and RGA (ORNL)
- Additional data on system performance

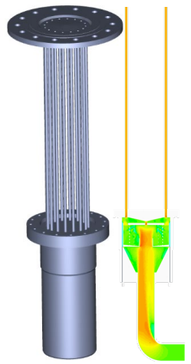
FY24 Operation of FASTR (ORNL/LTR-2024/3671)
- 11 aerosol tests
- Initial pump vibration data, ran 7 pump speeds
- E-Chem (ANL), pressure (SBIR), & flow (SBIR) run
- Raman probe (PNNL) exposed ~558h @ >500 C

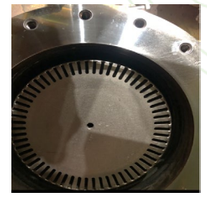
FY23 First operation of FASTR (ORNL/TM-2023/2846)
Operation of LSTL (ORNL/LTR-2023/3087)
- Initial 4 aerosol tests and Kr injection test
- Test flowmeter for VT (*NEUP*)
- Modeling info for SAM (ORNL) & MELCOR (SNL)
- Raman probe exposure (PNNL) & E-Chem sensor test (ANL)

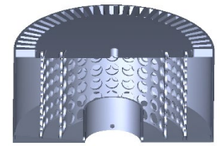
FY22 LSTL modification and preparation
- Installed new test section, filter, and piping
- CFD analysis investigating flow field and forces
- Installed Raman probe (PNNL) & E-Chem sensor (ANL)











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Facility to Alleviate Salt Technology Risks (FASTR)

- High-temperature forced-flow **chloride** salt test facility
  - Largest chloride salt loop for open R&D to have operated (in open literature)
- Current goals:
  - Novel sensor tests (flow, pressure, and species)
  - Demonstration of chemistry and corrosion control
  - Demonstrate and de-risk components
  - Digital twin development and integration

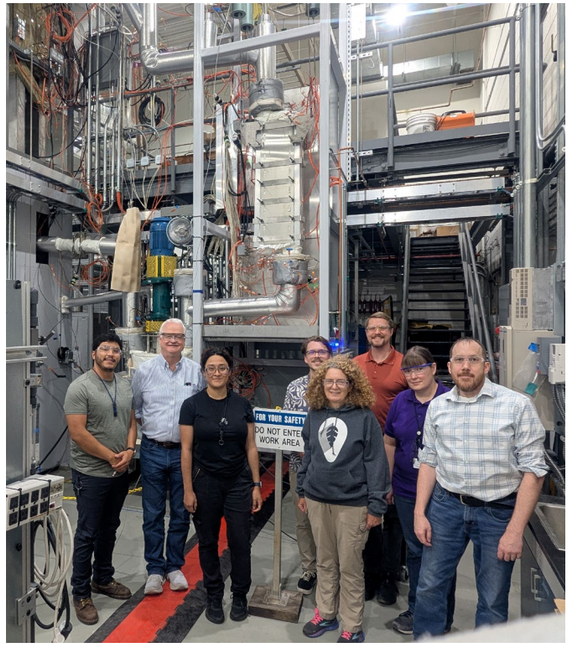
Purification Vessel

Salt	$NaCl\text{-}KCl\text{-}MgCl_2$
Operating Temp.	725°C
Flow rate	≤7.0 kg/s
Primary Material	C-276
Salt volume	155 L
Power	400 kW
Primary piping ID	5.20 cm
Initial operation	Dec. 2022

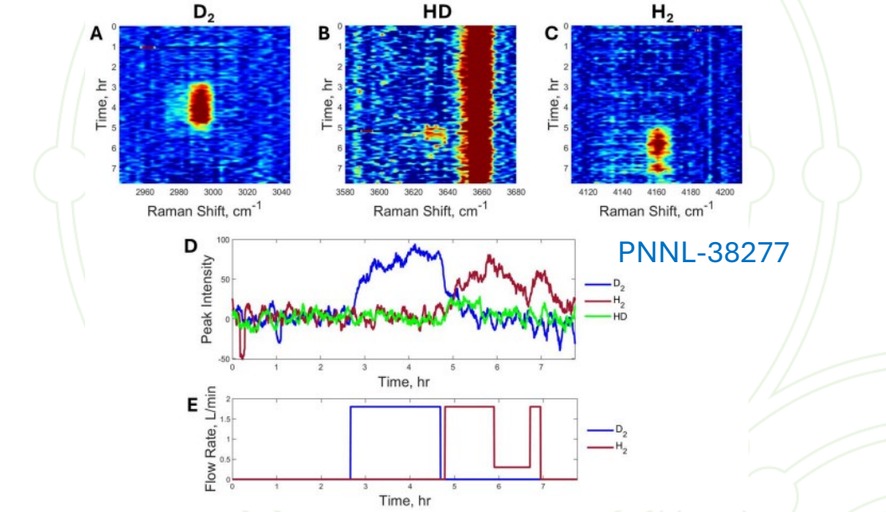
FASTR Forced-Circulation Loop

FASTR Progress FY25
(after previous campaign review)

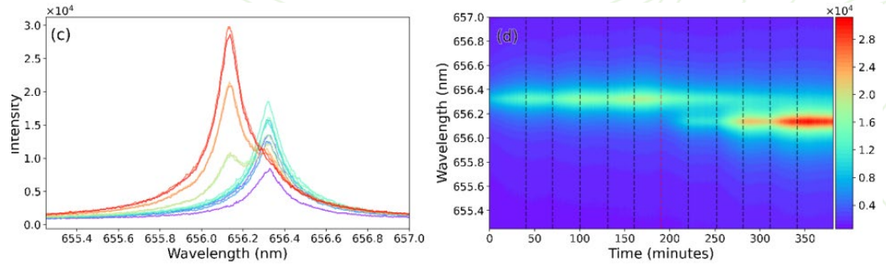
- Collaborative test campaign for specie detection:
  - Laser induced breakdown spectroscopy (LIBS, ORNL)
  - Residual gas analyzer (RGA, ORNL)
  - Ramman spectroscopy (PNNL)
- Timed gas injections
  - Storage tank: H_2, D_2, Xe, Kr
  - Pump tank: H_2, D_2
  - Loop piping: Xe, Kr
- Some reports out, more papers are in progress!



Example H_2, D_2, HD results from storage tank

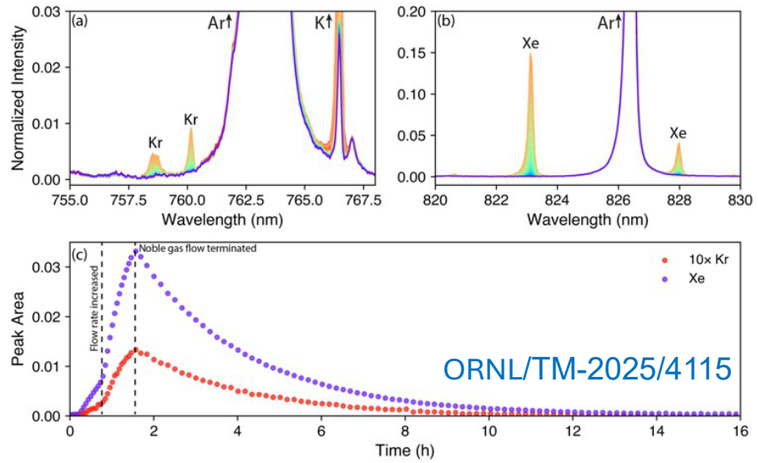


PNNL-38277



ORNL/TM-2025/4115

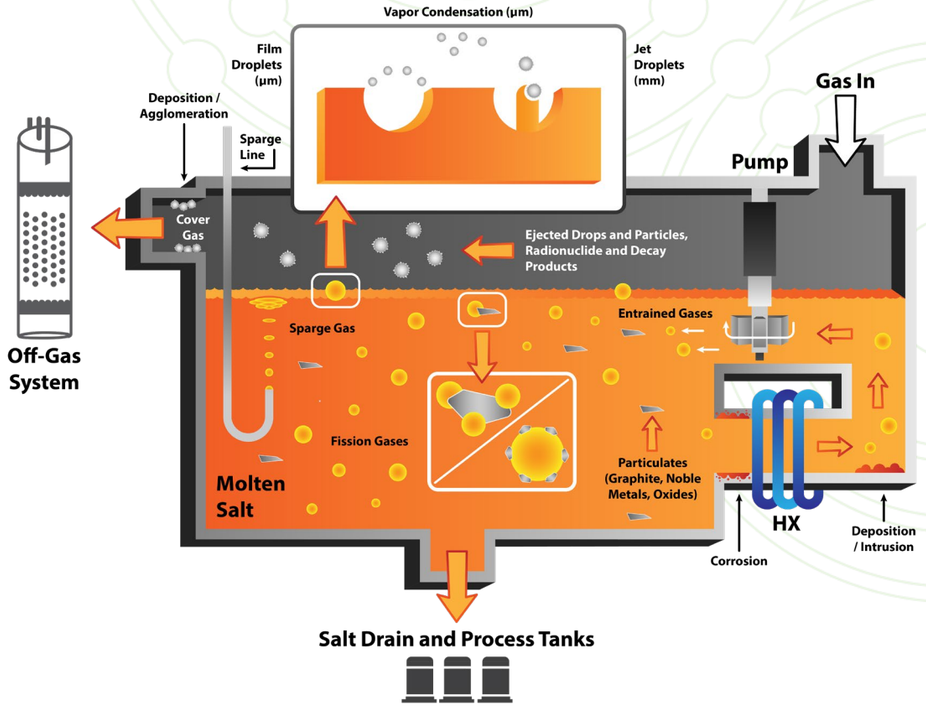
Example Kr, Xe results from storage tank



ORNL/TM-2025/4115

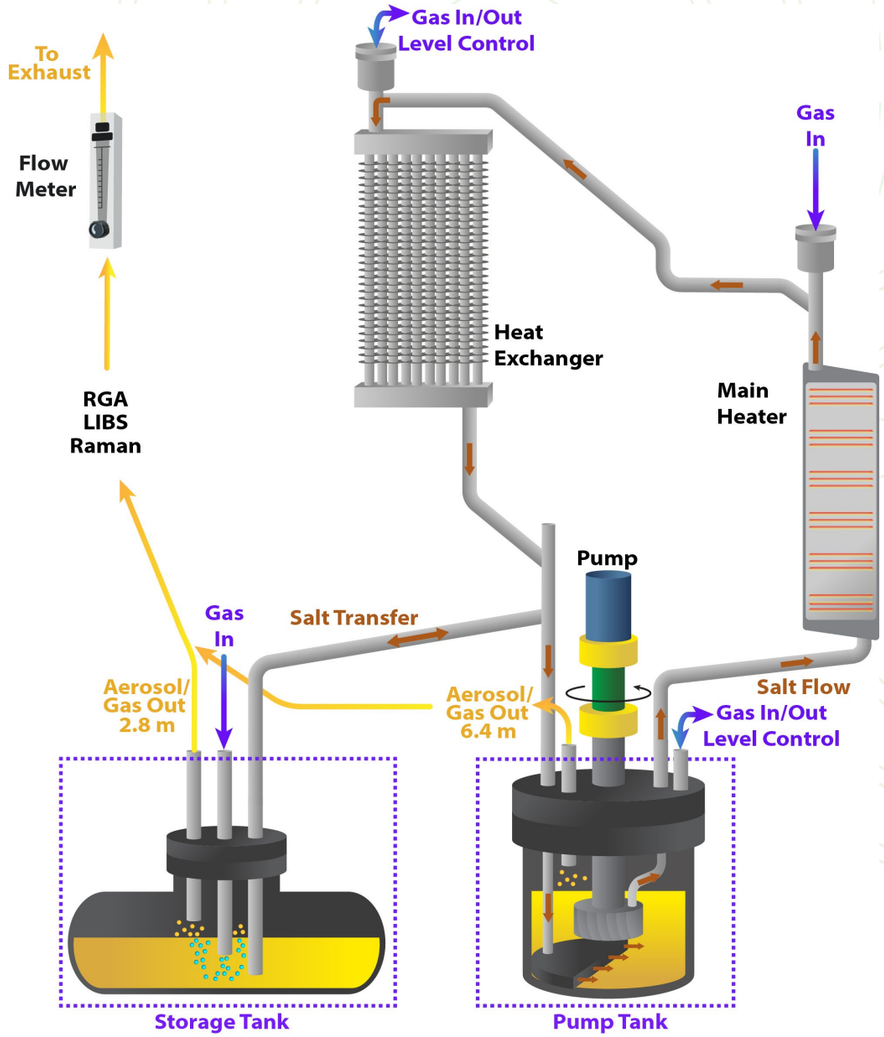
FASTR Progress FY25
(after previous campaign review)

- Several maintenance activities were completed
- Added tachometers to more-accurately measure pump speed
- Aerosol collection tests from pump tank
  - *Pump speeds: 0, 35, 40, 43, 43, 46%,* results still to be analyzed
  - Will form a nice dataset with FY24 storage tank tests (*ORNL/LTR-2024/3671*)
  - *LIBS detected aerosols in other off-gas locations (ORNL/TM-2025/4115)*
- ANL multifunctional voltammetry sensor was exercised
  - Salt has remained within an acceptable redox range for ~3.5 y
- Continued SBIR flow sensor testing
- *Journal paper in development summarizing commissioning activities.*



FASTR in FY26

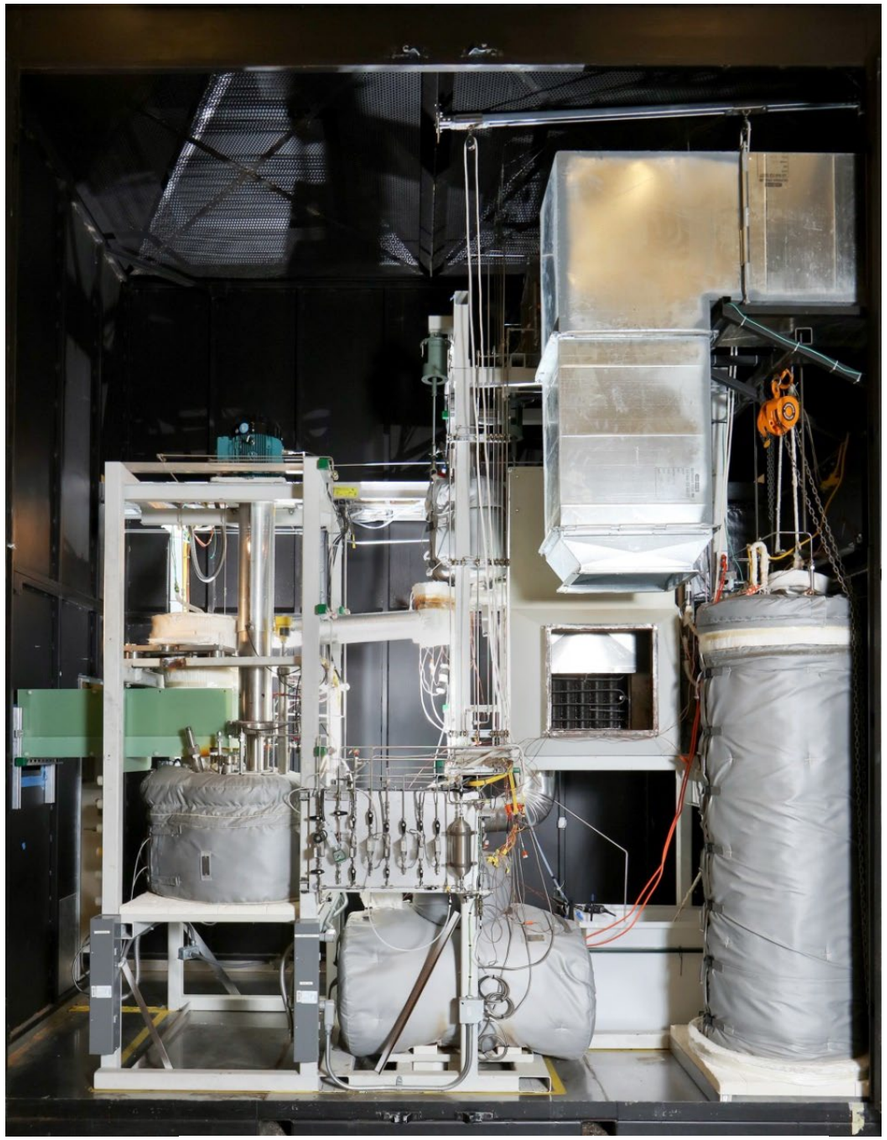
- Potential Plans:
  - 2nd round testing of specie transport measurements with gas injection into flowing loop
  - Complete adding pressure transducer near pump outlet
  - Continue testing flow meter(s)
- **FY26 effort focused on LSTL refurbishment**



Liquid Salt Test Loop (LSTL)

- Versatile high-temperature forced-flow **fluoride** salt test facility
  - One of very few salt loops in the U.S., with salt re-purification capability, with relevant power and flow
  - FLiNaK provides relevant salt environment for RD&D

Salt	NaF-KF-LiF
Operating Temp.	700°C
Flow rate	≤4.5 kg/s
Primary Material	Inconel 600
Salt volume	80 L
Power	200 kW
Primary piping ID	2.67 cm
Initial operation	Summer 2016



LSTL Forced-Circulation Loop

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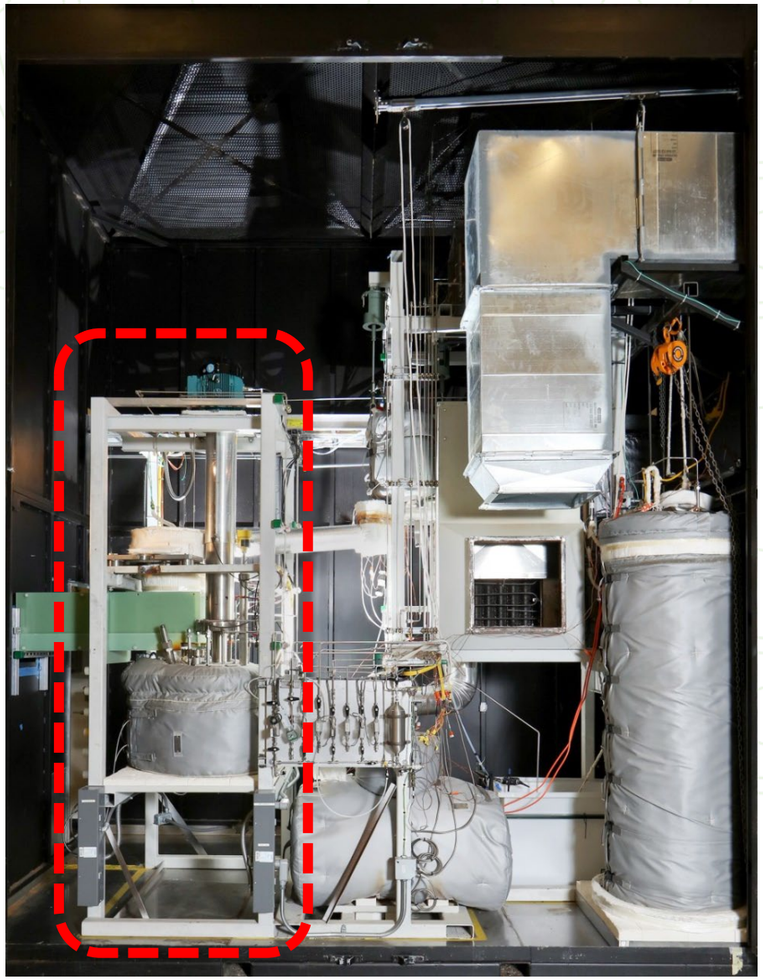
LSTL Context

- LSTL started as an ORNL Laboratory Directed Research and Development (LDRD) project in FY09
- DOE-NE later supported the inclusion of the salt purification system
- Salt Cooled High Temperature Reactors (FHRs, e.g. PB-AHTR) were the focus at that time
- LSTL pioneering development and impact:
  - Inductively heated pebble bed
  - Large SiC section as integral part of loop
  - Rotating metal-metal mechanical flange
  - SiC to metal flange
  - SiC-metal piston ring seal
  - Radar level gauge
  - Heated level gauges
  - Ultrasonic flowmeter
  - Dry gas pump seal application
  - Supported 7 student internships
  - LSTL experience supported ~8 NEUPs
- Effort shifted to FASTR operations after gas leak found in LSTL pump tank at end FY23
- After ~16y, LSTL is showing its age and requires refurbishment

Yoder, G., et al. "Development of a forced-convection liquid-fluoride-salt test loop." *Proceedings of HTR* (2010): 18-20.
Yoder, Graydon L., et al. "An experiment to study pebble bed liquid-fluoride-salt heat transfer." *Proceedings of ICAPP*. 2011.
Yoder Jr, Graydon L., et al. "An experimental test facility to support development of the fluoride-salt-cooled high-temperature reactor." *Annals of Nuclear Energy* 64 (2014): 511-517.
Yoder Jr, Graydon L., et al. "FLiNaK compatibility studies with Inconel 600 and silicon carbide," **NED**, 307, pp 172-180, 2016.
A 2017 write up on commissioning experience was published in 2023 (ORNL/TM-2023/2978)

LSTL Refurbishment Plans and Progress

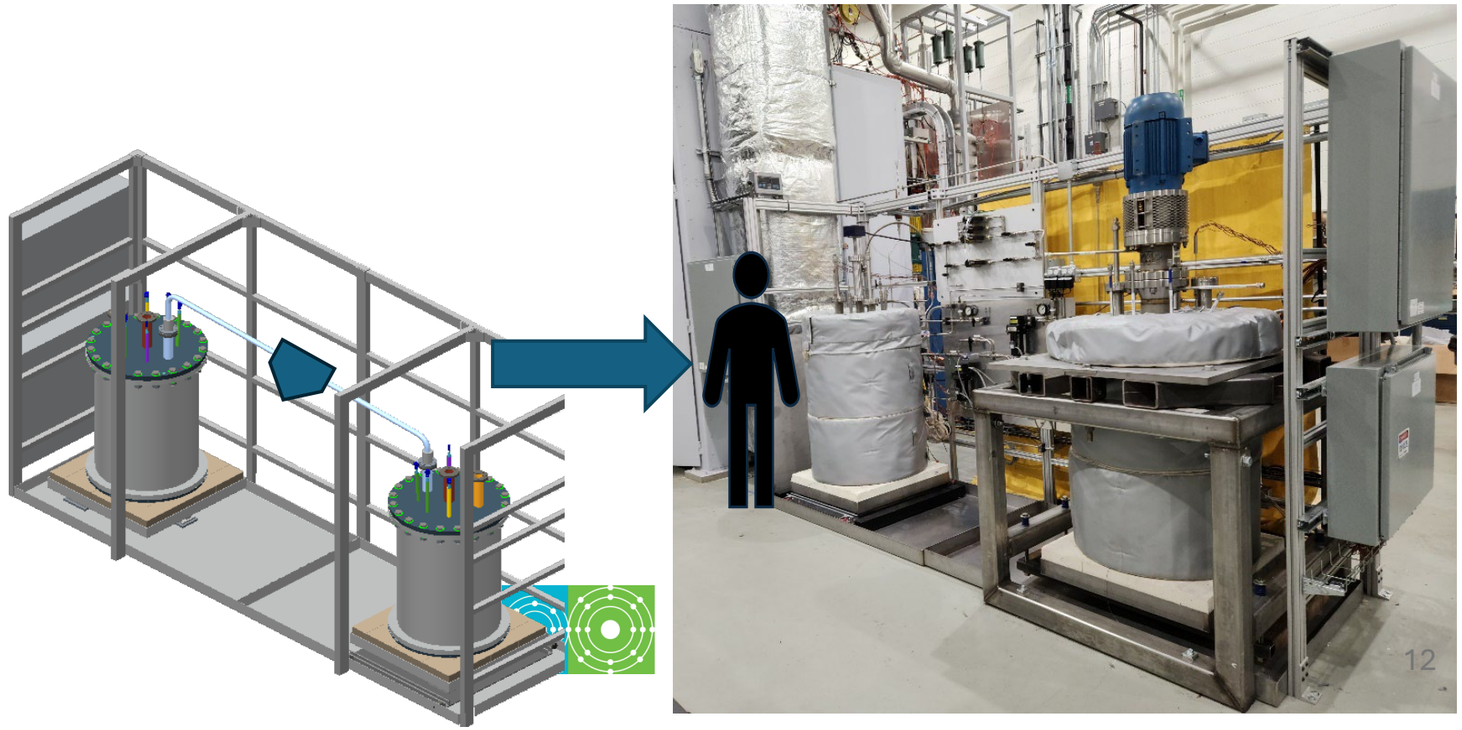
- Primary Goals:
  - Remove pump and pump tank
  - Replace with advanced manufactured tank and new pump
  - Enhance system compliance to newer DOE requirements
- Progress:
  - Planning discussions with Environment, Safety, Health and Waste representatives
  - Removed system insulation
  - Electrically isolated system and disconnected I&C
  - Engaged tank manufacturers and started tank design



Salt Pot Instrumentation and Components Evaluation Experiment (SPICEE)

- Update: Commissioning SPICEE in FY26 to test salt level and weight sensors
- Goal: understand uncertainty of associated measurements

	Updates
Salt	**FLiNaK**
Operating temp.	710°C @ 0.3 MPa_{abs}
Flow rate	≤5.8 kg/s
Operating pressure	Up to 0.3 MPa_{abs}
Primary materials	SS & Ni
Salt volume	120 liters
Power	~27 kW trace
Primary piping ID	~2.50 cm (1 in.)
Initial operation	**FY26**



Hydrogen And Salt Test Experiment (HASTE)

Coming Soon at ORNL!

Salt	NaF-KF-LiF, LiF-BeF_2
Design Temp.	650°C
Flow rate	8.5-22 kg/s (15-40 m^3/h) (65-175 gpm)
Primary Material	304H
Salt volume	240 L
Power	100-400 kW
Primary piping	3 inch (DN 80)

DOE Office of Science, Fusion Energy Sciences (FES)

↳ Fusion Innovation Research Engine (FIRE) Collaboratives

↳ Blanket Collaborative on Test Facilities (BCTF)

Goal: Advance the TRL of multiple fusion blanket concepts

↳ Hydrogen And Salt Test Experiment (HASTE)

Goal: Accelerate molten salt technology by building a component-scale facility to test industry-relevant test sections at relevant conditions

HASTE objectives:

1. Design and build HASTE using industry-relevant materials
2. Design and fabricate industry-relevant channel test section to study heating and MHD flows
3. Explore innovative pumping technologies, such as linear induction pump for molten salt
4. Detailed design of IFE test section to study internal convection heat transfer in blanket modules, jet dynamics and breakup, FLiBe vaporization and condensation

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October 27-29, 2026

Marriott Knoxville Downtown
Knoxville TN

Registration opening very soon

MOLTEN SALT REACTOR WORKSHOP 2026

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Thank you

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Reminder of Recent Journey

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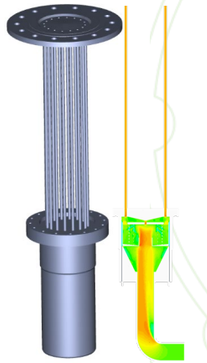

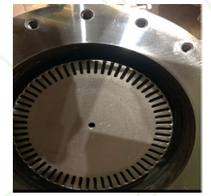

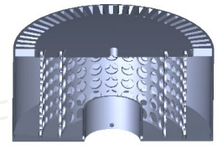

FY23

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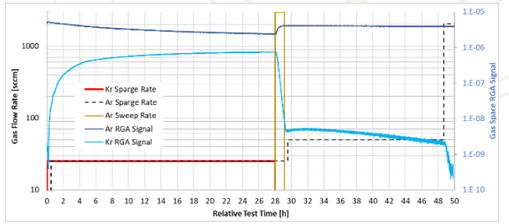

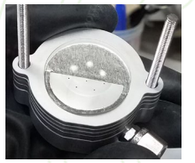

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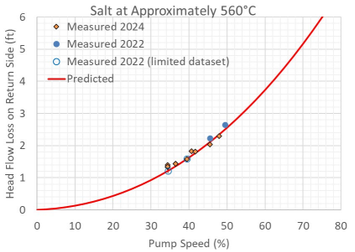

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FY26

LSTL refurbishment

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