NEXTRA
Nuclear Energy eXperimental Testing Research Alliance

ACU MSRR Systems Modeling

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representing the NEXT Research Alliance

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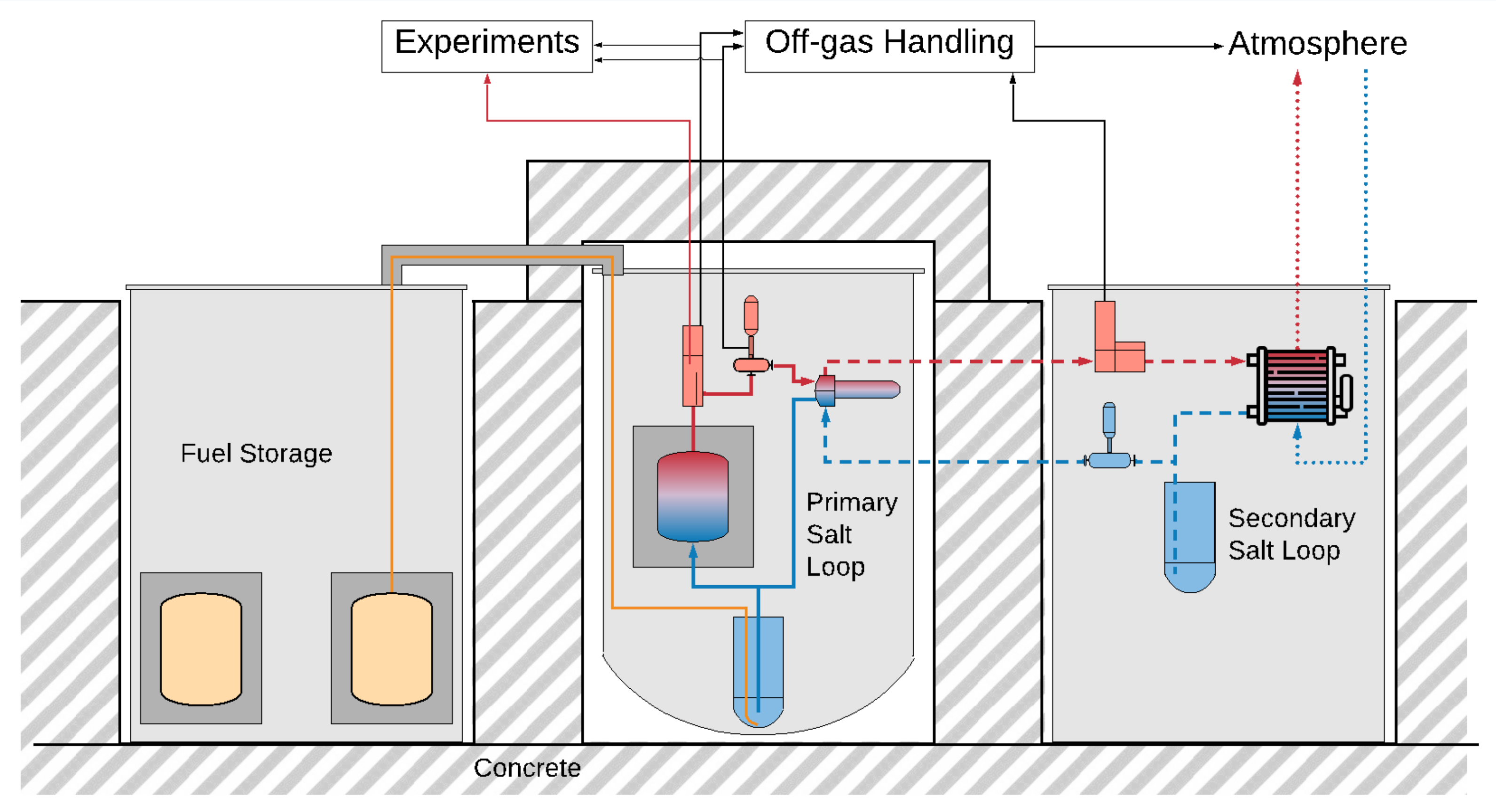
2016	2018	2020	2022	2024	2026
NEXT Lab formed at ACU to study MSR	NEXT Lab receives $3.5M in donations	NEXTRA formed and funded - $30M	Construction Permit Submitted to the NRC		

Construction started on the SERC facility

Operating license and first criticality



MSRE

shared concepts

- UF_4 $LiF\text{-}BeF_2$ fuel
- Loop design
- Graphite moderator
- Drain tank
- Trench-based radiation protection
- 5-years of full-power operation

MSRR

simplified concepts

- 19.75% instead of 33% ^{235}U
- 1 MWth instead of 8-10 MWth
- SS-316 instead of Hastelloy-N
- No rad-gas management system required
- Utilizing 50 years of technology advancement

What are the key goals?

Demonstrate licensing

- Develop advanced reactor licensing experience: for NEXTRA and the NRC

Establish initial supply chain

- Construction and supply chain have plagued traditional and advanced reactor concepts

Generate operational data

- Demonstrate molten salt chemistry management
- Qualify nuclear software
- Understand material accountability challenges

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Requirements for System Code Selection

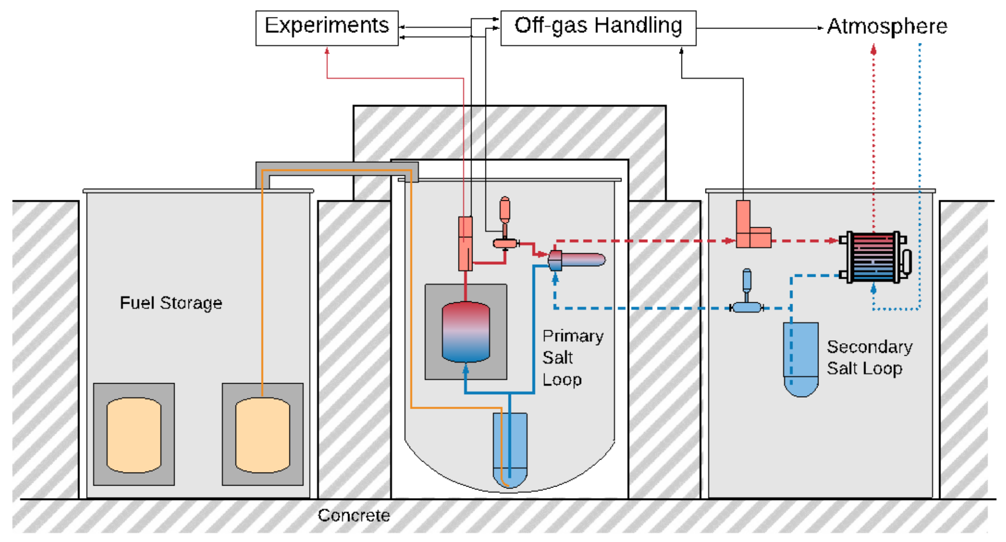
- Input to Design/Operations/MHA
  - Maximum power during transient
  - Maximum temperature of materials
  - Maximum/min salt temperature
- Validated for the leading physics
  - Neutron kinetics
  - Thermal-fluid dynamics
  - System-responses
- Soft Requirements
  - Complete and available
  - Familiar to the NRC
  - Used with operating reactors
  - Familiar to the NEXTRA team
  - Capable of being extended
- Not requirements
  - NQA-1 approved development process
  - Accounting for all of the physics

RELAP5-3D

- Simplified Physics
  - 1D channel flow with conduction in solids
  - Point Reactor Kinetics (and 3D)
  - Operator and safety system models
- Extended (by INL through a GAIN Voucher)
  - Thermophysical properties for multiple salts
  - Added flowing fuel neutron kinetics
- Sufficient, but not ideal
  - Meets the requirements, but lacking physics for a commercial system

Key Contributors

- Mark Kimber (Texas A&M)
- Kraig Farrar (Texas A&M)
- Jonathan Scherr (ACU)
- John Ross (Texas)
- Yong Joon Choi (INL)



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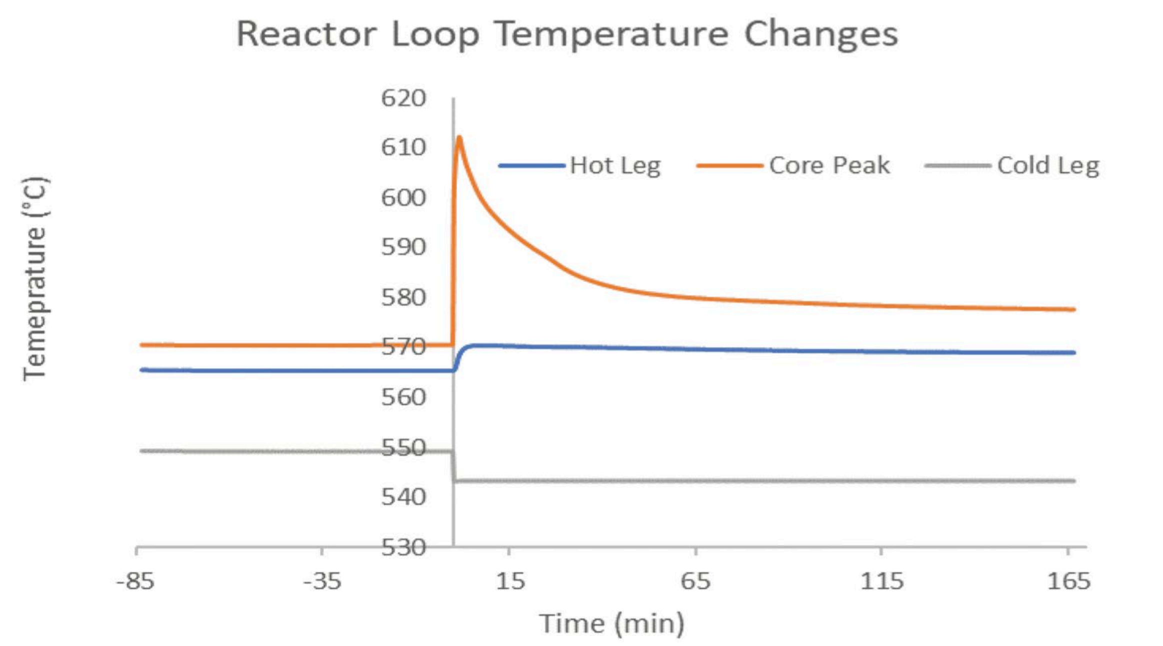
Accident Analyses

- Salt Spill Accidents (MHA)
- Cooling Anomalies
- Fuel Handling Anomalies
- Reactivity Insertion Accidents
- Surveillance System Malfunction
- Loss of Electrical Power
- External Events

Preliminary SAR

- https://adams.nrc.gov/wba/
- ID: ML22227A203
- Chapter 13: Accident Analysis

Figure 13.1-5 Hot Leg, Cold Leg, and Center Channel Peak Temperatures on Pump Failure



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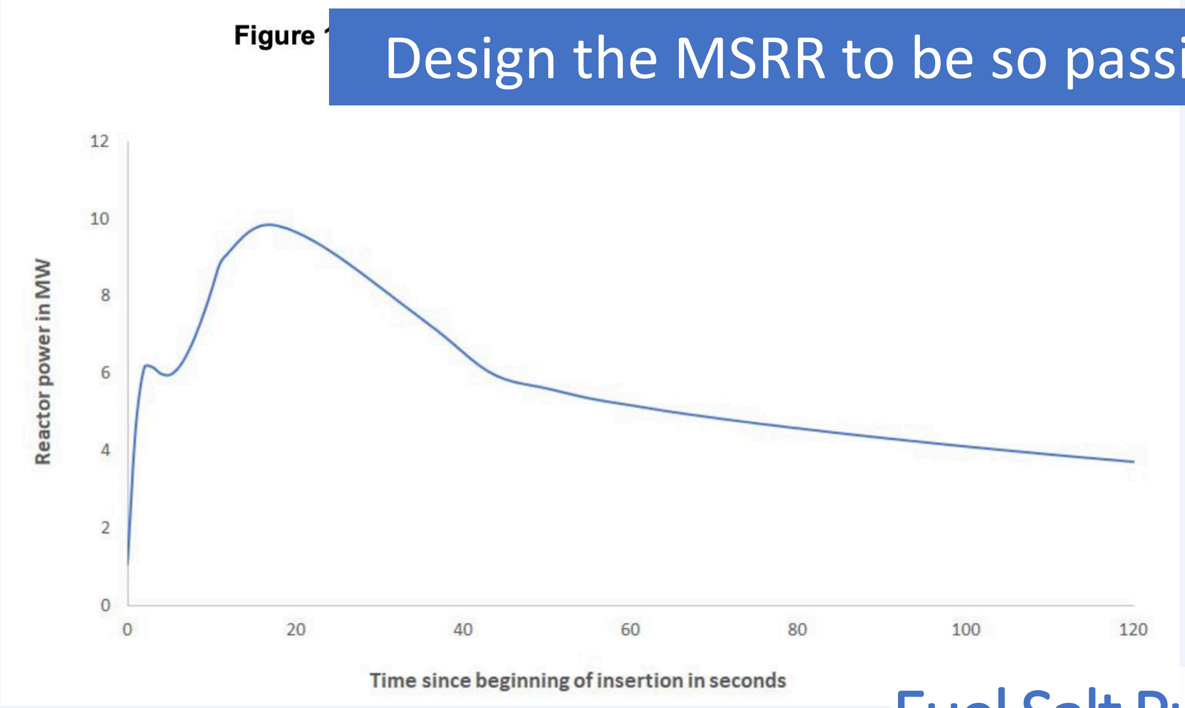
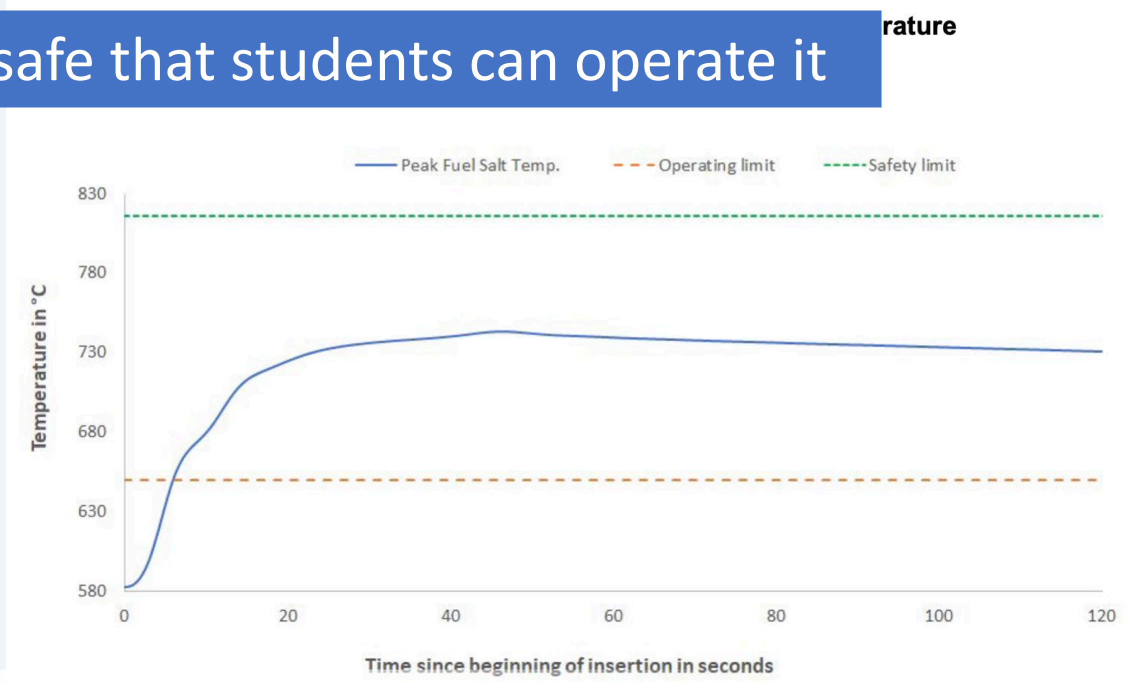
Limiting Reactivity Insertion Accident

Design the MSRR to be so passively safe that students can operate it





Fuel Salt Pump Failure (70 pcm)

- Gas in coolant leaves core increasing density (400 pcm)
- Xenon (in gas) leaves core (120 pcm)
- Control rods errantly slowly withdraw (190 pcm)
- No SCRAM (fuel salt draining)

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Future System Modeling Code Options

Requirements

- Account for all of the physics
- Informed with higher-resolution software
- Strong software quality assurance
- Verified through numerical analysis
- Validated with SE and IE tests
- Calibratable from MSRR data
- Integrated optimization and UQ
- Integrated engineering analysis and visualization
- Coupled with scientific surveillance layer

Options

- Near-Term
  - SAM[X]
  - MELCOR
  - VERA-MSR
  - GenFOAM
    - Each can include all physics
    - All utilize simplified physics and geometries
- Long-Term
  - Pronghorn+Griffin[X]
  - Shift+NEK-RS[X]
    - Extensible to include all physics in the future
    - Utilize highest-resolution physics/geometry

[X] Actively funded by DOE-NE

Commercial reactors will be optimized to operate closer to design limits

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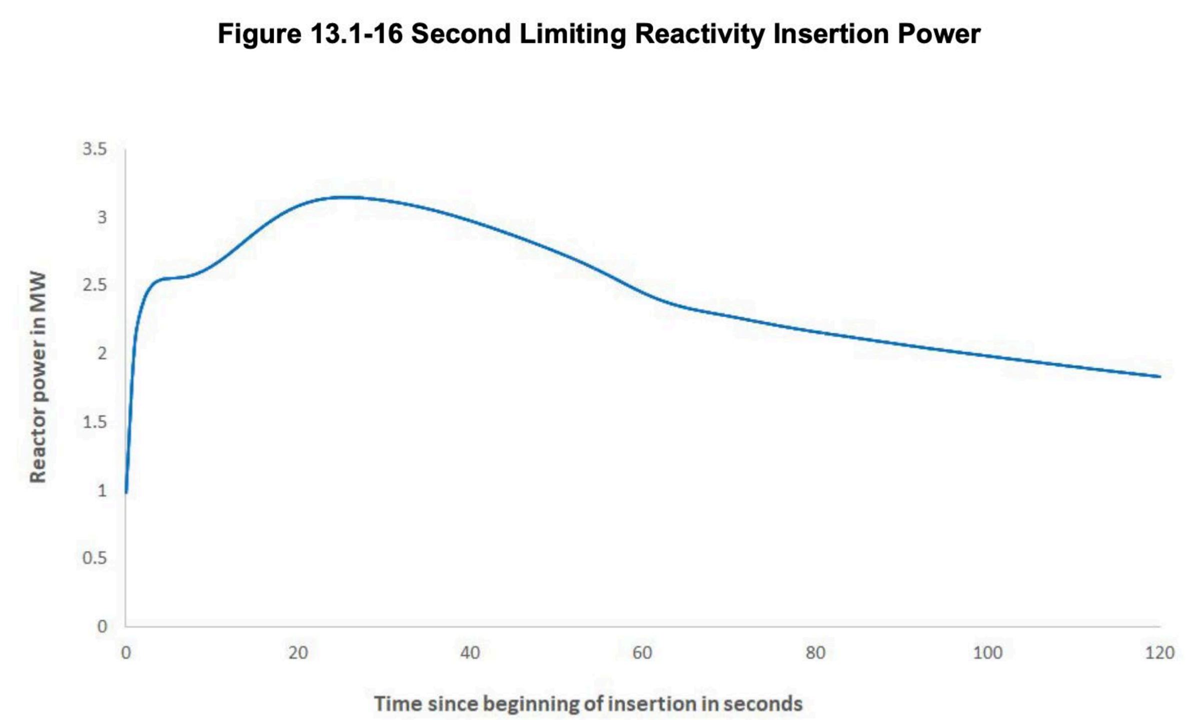
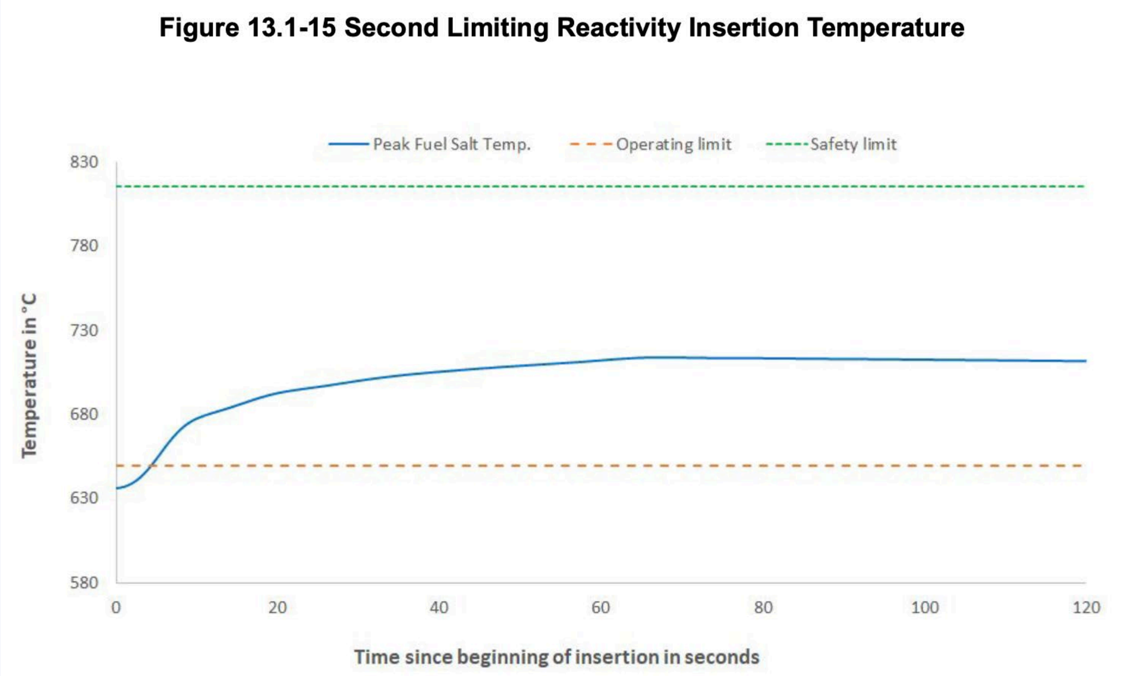
Backup Slides

Limiting Reactivity Insertion Accident





Collapse of all bubbles in salt

- With Loss of Cooling (Pump Trip)
- 420 pcm total insertion over 26 seconds