



# Safety Considerations for Advanced Material Irradiation at the ATR

June 2024

*Changing the World's Energy Future*

Daniel Kelly Sluder, Nate Oldham, Jacob Lewis Westacott, Duane Ball



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**Idaho National Laboratory  
Idaho Falls, Idaho 83415**

**<http://www.inl.gov>**

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**Daniel K. Sluder, PE**  
ATR Experiment Engineer

# Safety Considerations for Advanced Material Irradiation at the Advanced Test Reactor

Daniel K. Sluder, R. Duane Ball, Nate S. Oldham, Jacob L. Westacott

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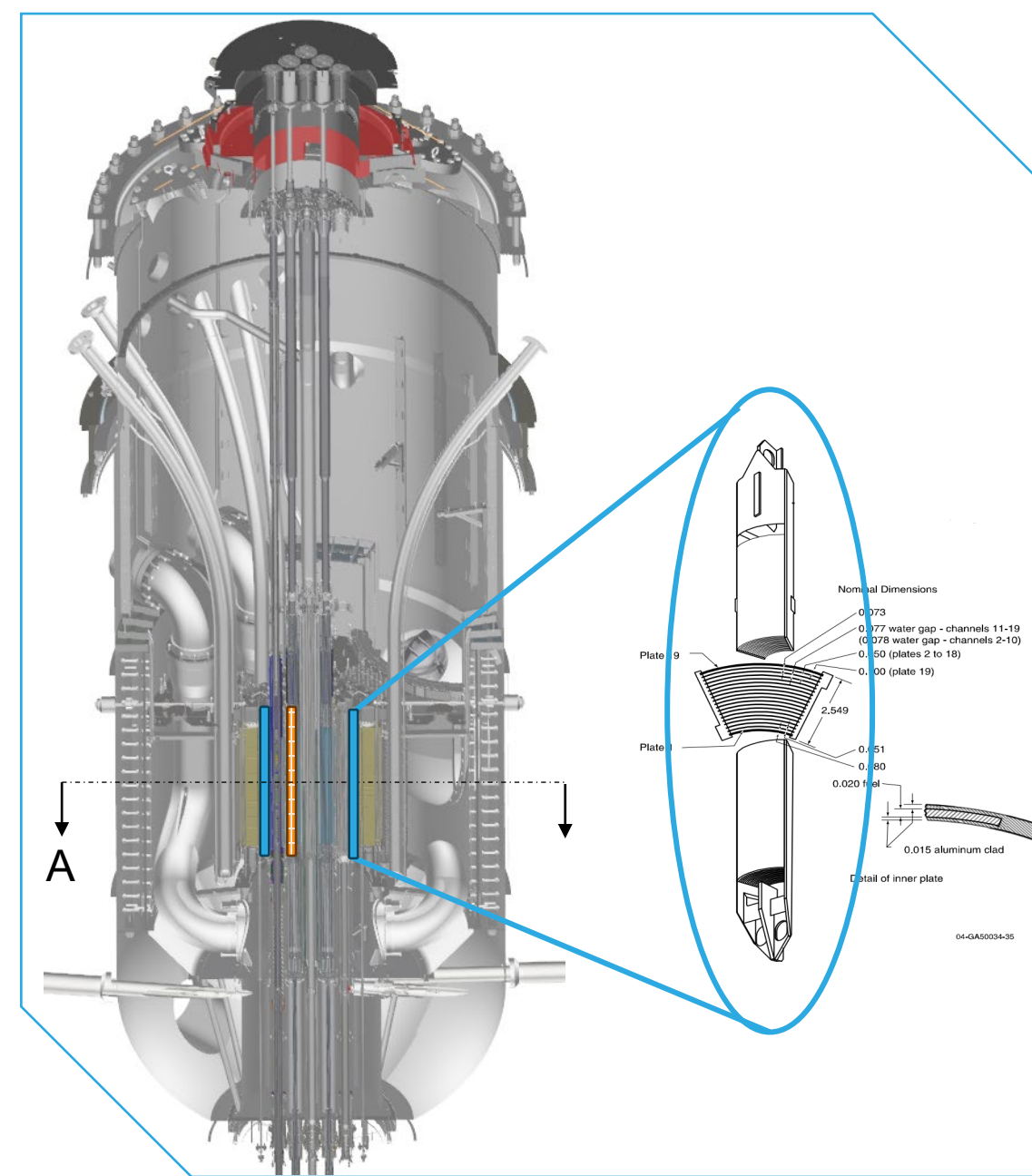
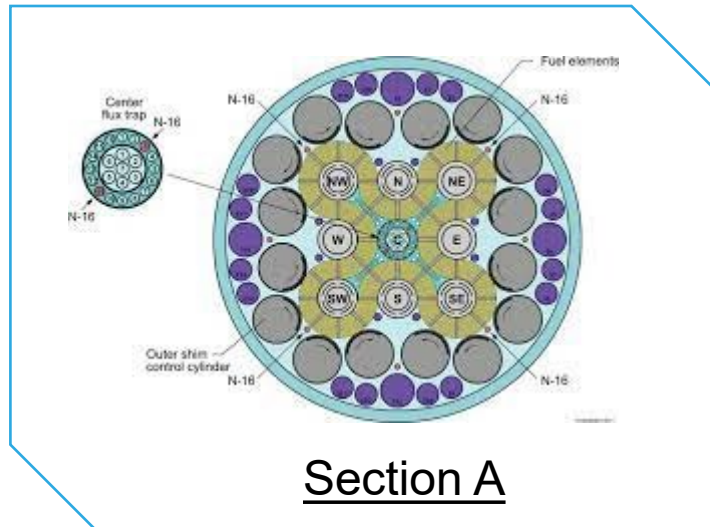
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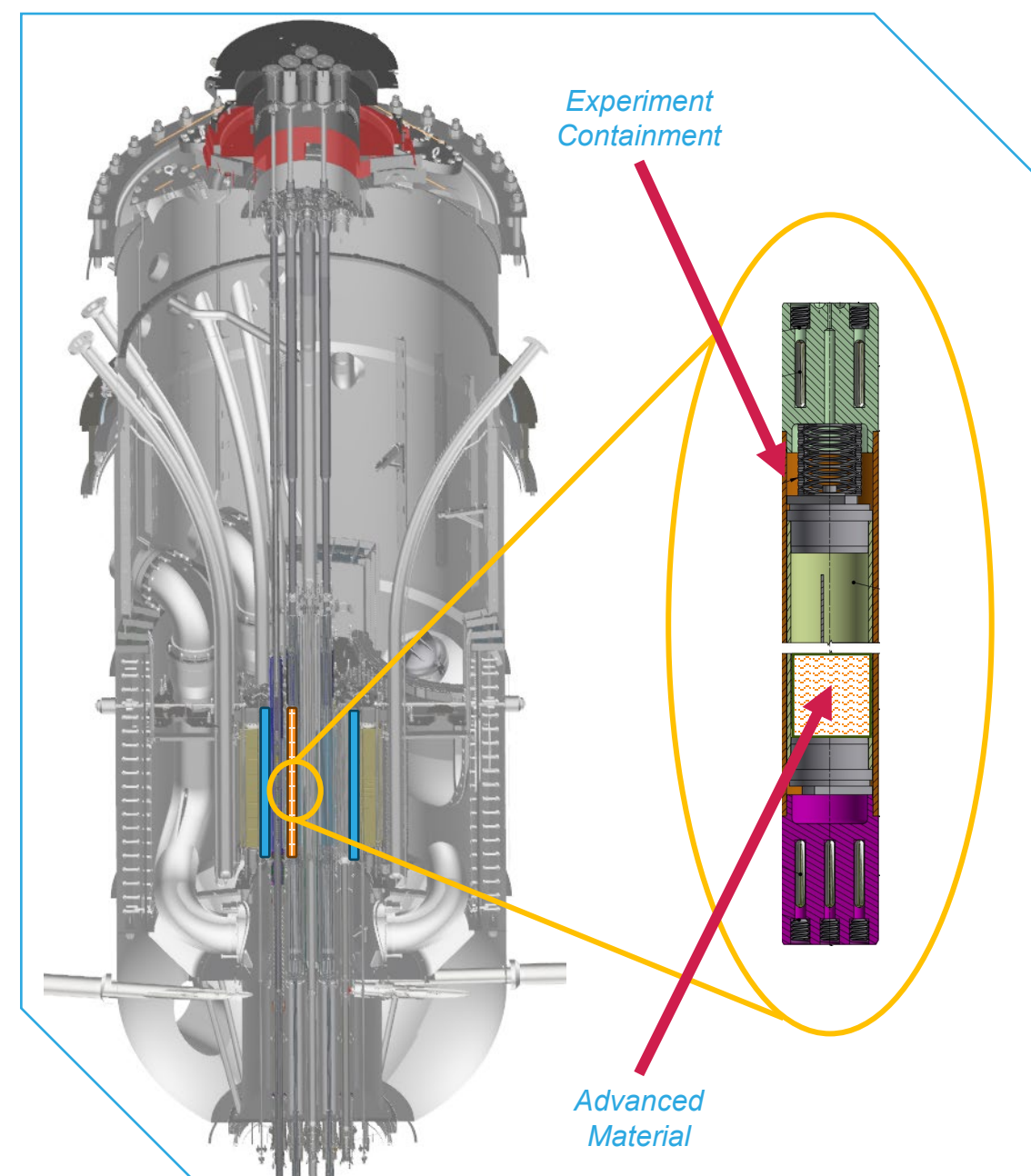
# Advanced Test Reactor Description

- 250 MW<sub>t</sub> Core Power
- Light Water Reactor
- Aluminum Clad Driver Fuel
- 77 Test Positions



# Next Generation Experiments

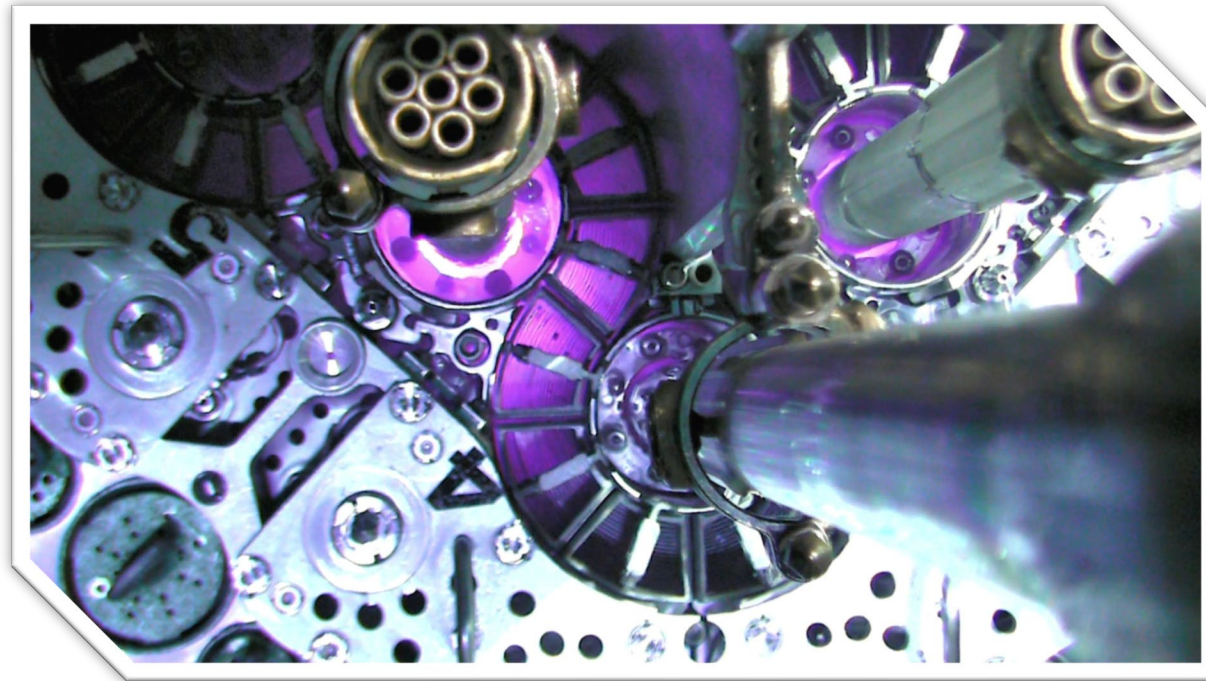
- Next generation reactors require irradiation of “Advanced Materials”
- Advanced Material Examples:
  - Sodium bonded fuel
  - Molten Salts:
    - $\text{NaCl-UCl}_3$
    - $\text{UF}_4\text{-NaF-KF}$
  - Other compounds:
    - U-Fe
    - Molten Tin



# Safety Considerations for Advanced Material Irradiation

Three primary considerations:

1. Experiment Containment Design Criteria
  - Failures must be low frequency
2. Material interaction considerations
  - If failures occur, driver fuel cannot be damaged
3. Dose consequence analysis
  - Release from molten fuel experiments must be considered



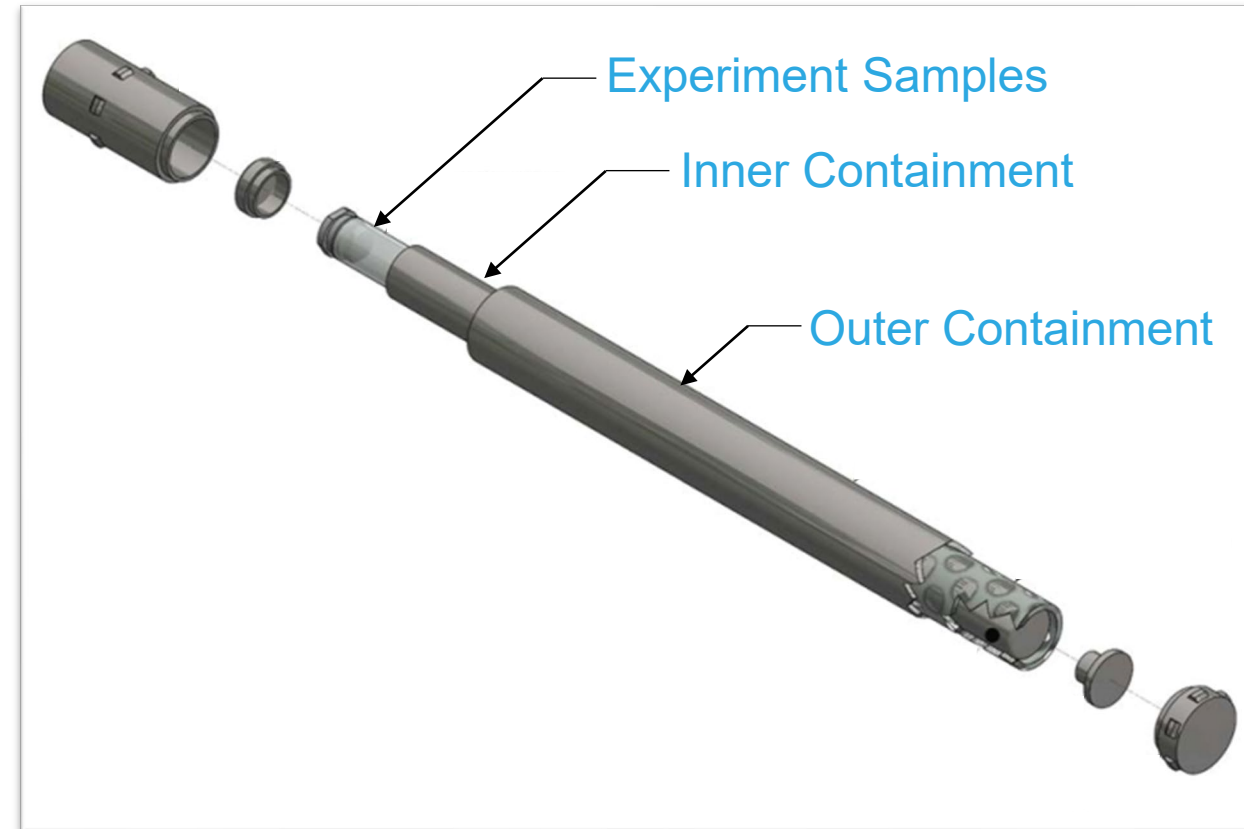


# 1. Experiment Containment Design Criteria

- Legacy experiment designs used a design-by-rule philosophy (ASME Section III)
- Developing a Load and Resistance Factor (LRF) Design Methodology

$$\sum \gamma_i Q_i \leq \phi R_n$$

- $Q_i \equiv$  Loads
- $\gamma_i \equiv$  Primary load effects
- $R_n \equiv$  Material resistance (allowable stress)
- $\phi \equiv$  Material resistance factor

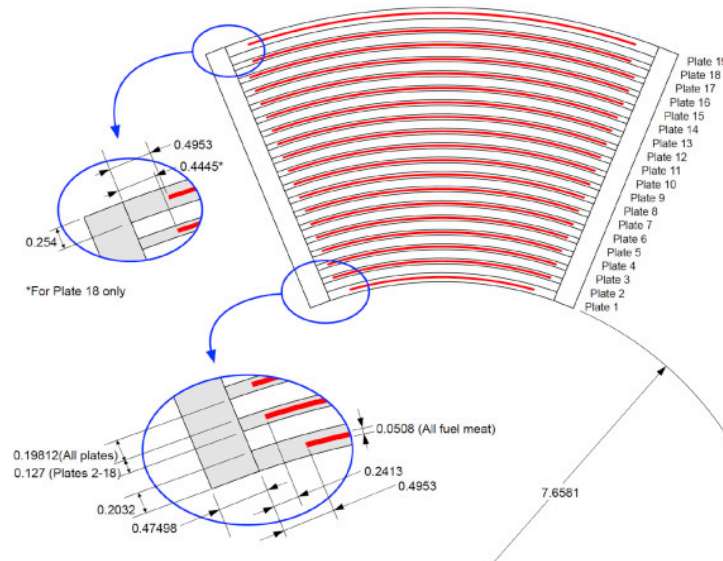


Simple Experiment Capsule

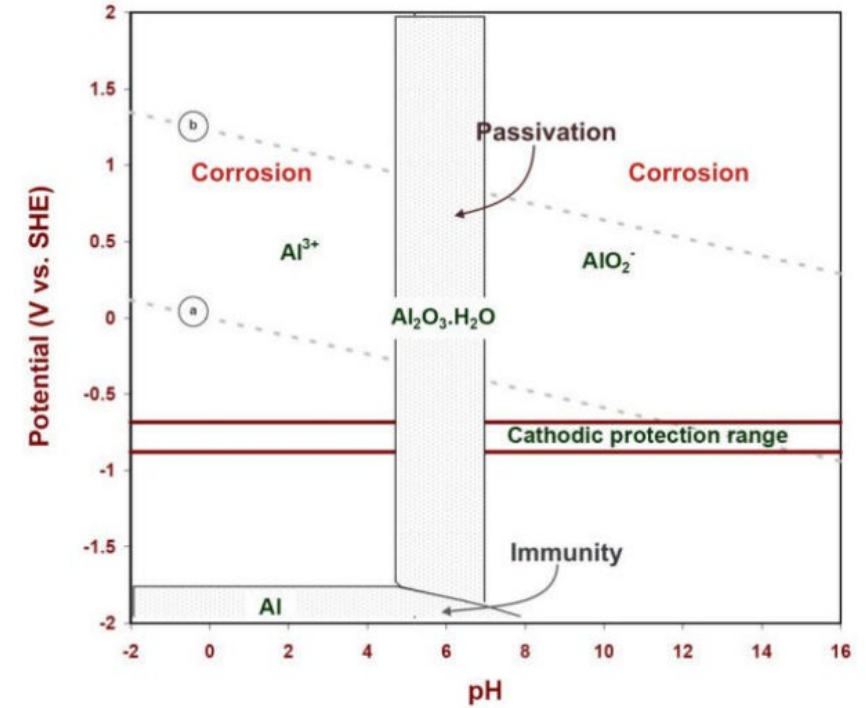


## 2. Material Interaction Considerations

- Experiment failure and material release is a design basis event
- Driver fuel must be protected
  - Aluminum clad
  - Boehmite corrosion layer
  - Protected with a tight coolant chemistry controls



Driver fuel cross section



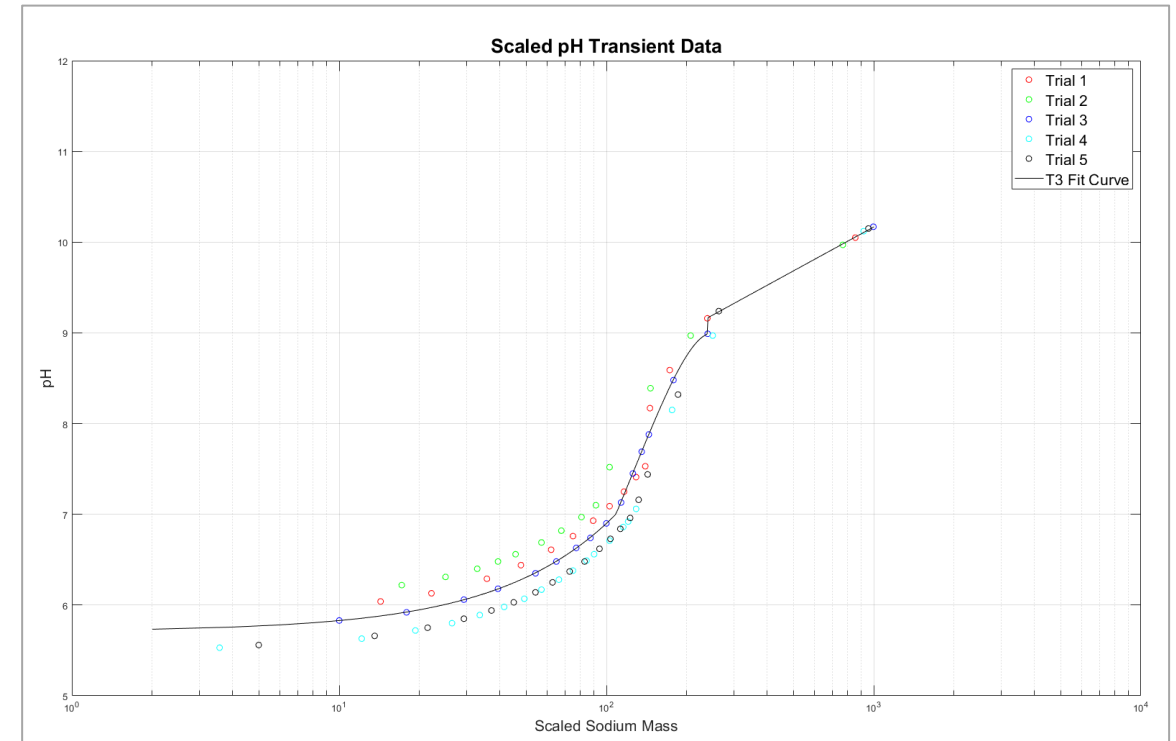
Passivation in Boehmite  
[P. R. Roberge, "Corrosion Engineering"]

## 2. Material Interaction Considerations

- Material titrations are performed to quantify response curve
- Material limits set such that failure doesn't exceed actionable levels.



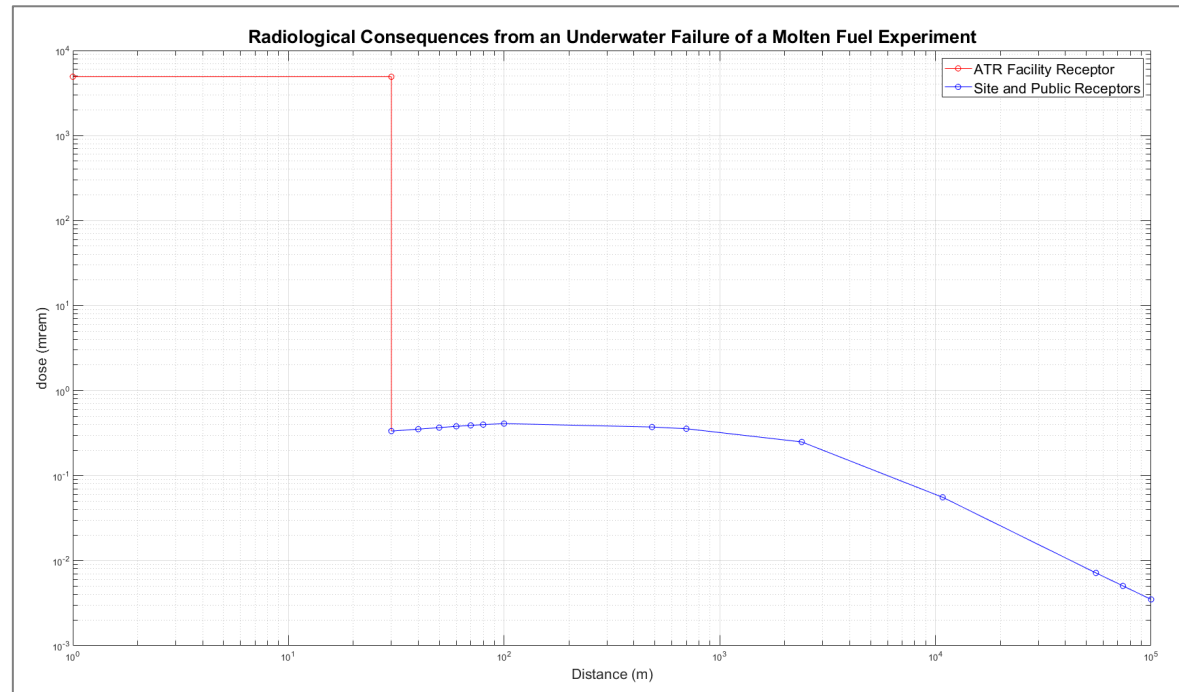
*Sodium titrations performed  
on primary coolant*



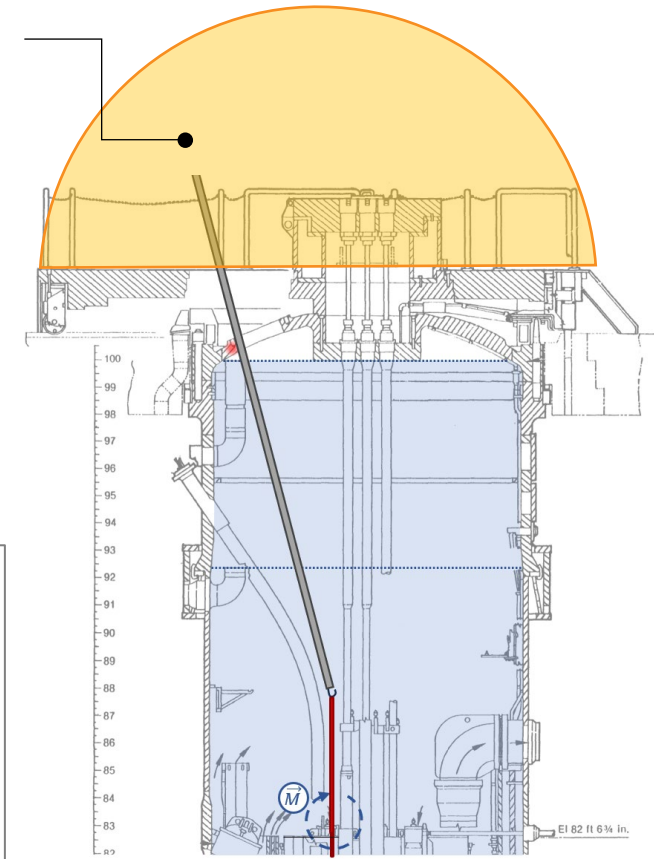
*Scaled Titration Data*

### 3. Dose Consequence Analysis

- Many experiments are manually handled
- Handling damage is a design basis event
- Analysis considerations:
  - Facility and public receptors
  - Molten release
  - Water retention



Receptor



*Potential moment applied to target assemblies during removal from the reactor vessel*



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