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Sodium Metal Fires and Advanced Reactor Safety

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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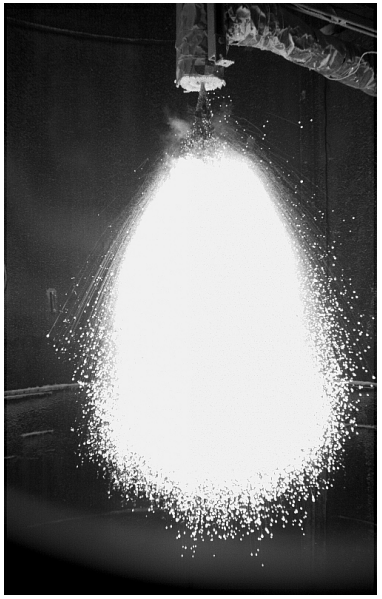
Programmatic Motivation

- Nuclear energy is undergoing revitalization in the U.S.
  - Significant commercial interest in building new capacity
  - New reactor designs being proposed and evaluated
  - FCT - DOE Fuel Cycle Technology- Proliferation resistant and transmutation technology
- Fast reactors:
  - Use of liquid sodium for neutronics and cooling
  - New fuel fabrication and fuel reprocessing facilities
- There are serious safety implications for these facilities
  - Accidents involving sodium leaks resulting in fires

Sodium Fire Risks

- Significance of the fire hazard:
  - Highly reactive and energetic materials
  - Critical components vulnerable to thermal damage
  - Nuclear materials can be dispersed through vaporization, boiling of other components and through particle entrainment



- Hazard mitigation required during regular operation, transportation, maintenance

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Technical Approach

Program involves three coordinated areas of study:

- **Reactor design and safety assessments**
  - **General literature review**
  - **Review proposed reactor designs**
  - **Identify credible risk scenarios involving sodium**
- **Discovery experiments**
  - **Identify key but poorly understood phenomena (PIRT)**
  - **Design and execute experiments to explore identified phenomena and to support model development and validation**
- **Development of analytical tools**
  - **Build on existing SNL analysis tools**
  - **Identify model shortcomings**
  - **Develop and validate models through comparison with experimental measurements.**

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Experimental Program

- **Sodium Spray Fires Experiments**
  - **2 outdoor and 2 in-vessel experiments**
  - **Measured spray heat fluxes and temperatures**
  - **Varied average droplet diameters and sodium temperatures**

- **Sodium Pool Fire Experiments**
  - **11 outdoor experiments**
  - **Measured surface heat fluxes and pool temperatures**
  - **Varied thickness ratio of the stainless steel substrate to the liquid sodium**

Sodium Outdoor Spray Test Setup

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Sodium Spray Fire Experiments: Outdoor Spray Video

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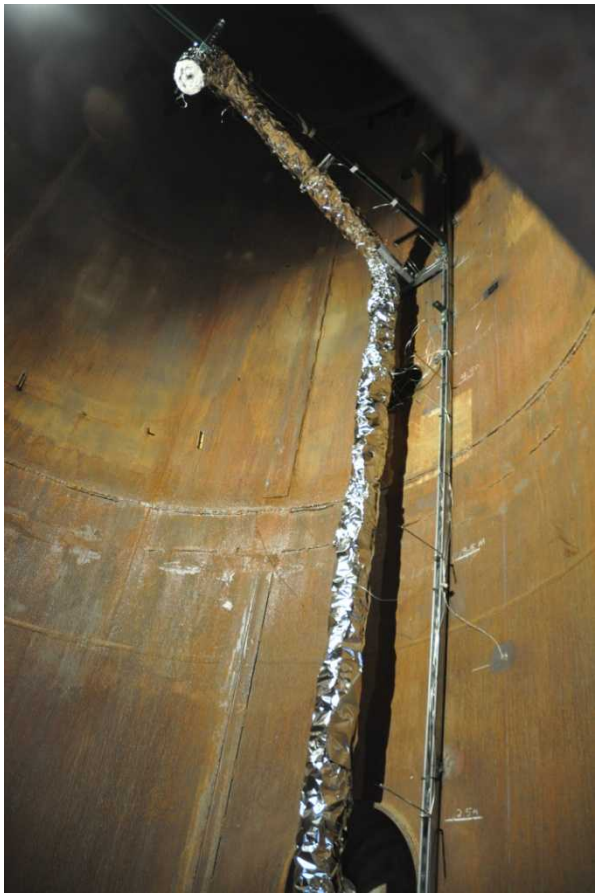
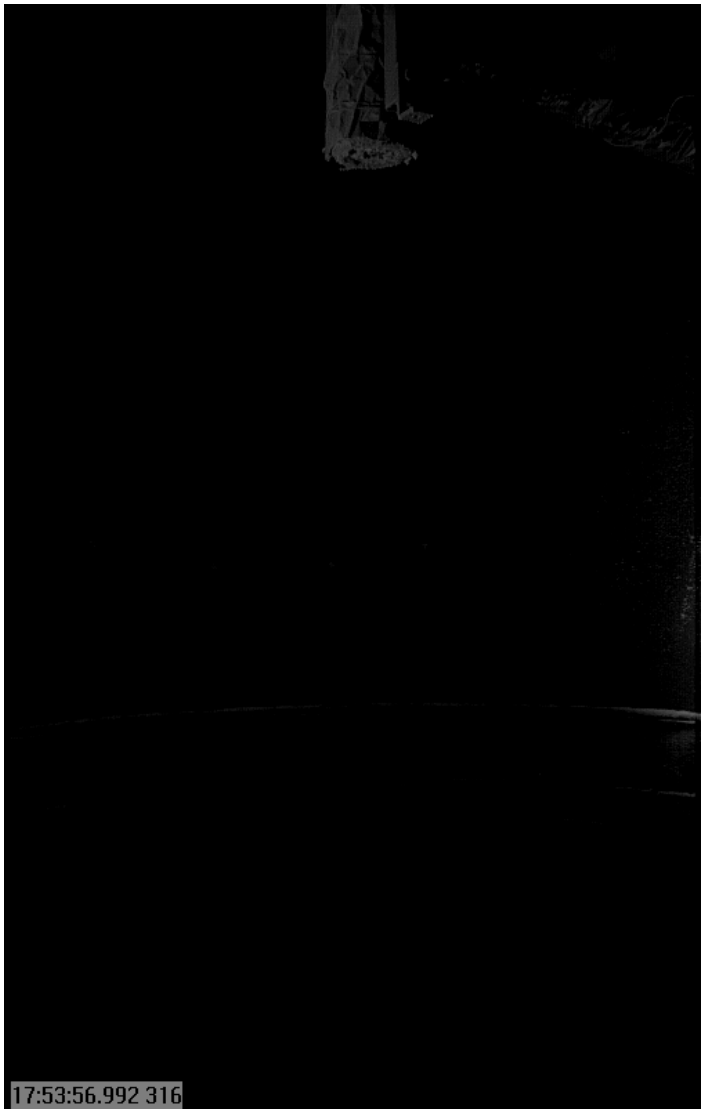
Sodium In-Vessel Spray Test Setup



Sodium Spray Fire Experiments: In-Vessel Spray Video



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Sodium Pool Fire Test

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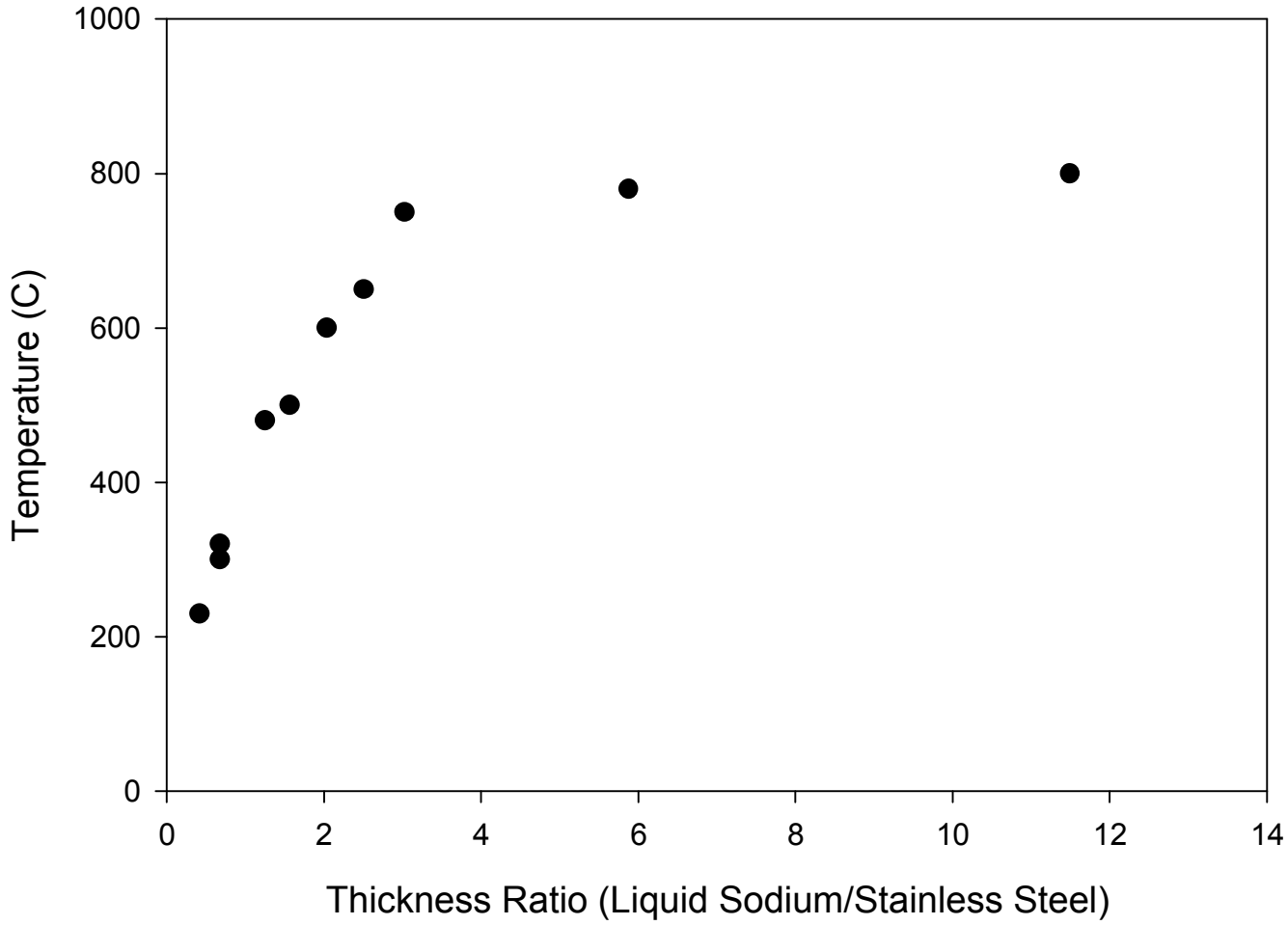
All Sodium Pool Tests: Measured Peak of Average Bottom Pan Temperature vs Thickness Ratio (Liquid Sodium/Stainless Steel)



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Future Work

- **Sodium Pool Burning**
  - **Improved pool burning model requires many poorly characterized parameters. Recommend experimental characterization of:**
    - **Oxide crust (porosity and composition)**
    - **Sodium liquid spreading (including freezing)**
    - **Mass of oxide that sticks (versus aerosolized)**

- **Sodium Spray Fires**
  - **Based on LDRD discovery experiments, improvement for future test series include:**
    - **Elimination of sodium vapor formation before test. This will allow better heat flux measurements.**
    - **Other diagnostics: floor vessel temperatures, aerosol characterization, oxygen consumption, spray characterization**

Questions/Comments

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