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Title: Design of a Critical Experiment to Validate Yttrium Hydride at Varying Temperatures

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Design of a Critical Experiment to Validate Yttrium Hydride at Varying Temperatures

June 2020

ANS Annual Meeting

Theresa Cutler, Travis Grove, Kelsey Amundson, Holly Trelue

Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

• **Microreactor Applications**

- Attractive technology for kick starting nuclear innovation
- Emerging nuclear energy source for microgrids, mining/industry, and remote applications
- Expectations of moderator material
 - Reduces required fuel masses and/or enrichments
 - Research best moderator to achieve this goal
 - Low-Z and High-Z combined compound seems most promising
 - Yttrium hydride retains hydrogen to higher temperatures than other moderating material
- Current Work
 - Many thermomechanical material properties of unirradiated material are known
 - Recent Thermal Scattering Law was developed for H-YH₂ in ENDF/B-VIII.0
 - Expected high performance at elevated temperatures
- Need an integral experiment to validate neutronic and kinetic performance

Motivation

- **Yttrium dihydride YH_2 is a promising candidate for moderator applications**
 - High thermal stability compared to other metal hydrides
 - Significantly reduces critical mass
- **Lots of material property measurements of unirradiated material have been made**
- **$S(a,B)$ in ENDF/B-VIII.0 exists for YH_2**
- **Many differential measurements across DOE**
- **Integral experiment is required to verify cross section and behavior in a critical environment.**

Experimental Objectives

- **Measure reactivity with central region heated**
 - Various points from 20 C to 330 C
 - Compare the change in reactivity at these points
 - Repeat without YH_2 in central region
- **Why not heat all?**
 - Decouple many competing effects
 - Reduce heating elements needed
 - Reduce time to heat the region
- **Why limit to 330 C?**
 - HEU metal used in not alloyed
 - Staying away from HEU phase transition

Experiment Design

- Planet Critical Assembly Machine

- Stacking

- Series of 6" Nominal OD parts
- YH_2 , made at LANL
- C-discs in Inventory
- Be discs in Inventory
- New graphite spacers
- Heaters

Heater

- Reflector

- Layers of Be blocks in NCERC Inventory

MCNP® Rendering of the YH_2 Experiment

HEU Fuel

- **General information**
 - Commonly referred to as “C-discs”
 - 6 total
 - Bare/ unclad

Yttrium Hydride

- **Manufacturer**
 - LANL
 - 14 discs per can
 - 2 layers of discs per can
- **Canning**
 - Molybdenum
 - E-beam welded closed
 - vacuum
- **Can Dimensions**
 - OD: 6.00 inch
 - ID: 5.80 inch
 - Height: 1.00 inch
 - Top and Bottom Height: 0.02 inch
- **YH₂ Disc Dimensions**
 - OD: 1.930 inch
 - Height: 0.480 inch

YH₂ plates in MCNP®

YH_{1.9}

Heaters

- **Manufactured by NASA**
 - Alumina outer surfaces
 - Graphite inner heating element
- **Dimensions**
 - OD: 5.85 inches
 - Height: 0.406 inches

Material ~ Alumina

Material ~ Graphite

Material ~ Aluminum

Material ~ Stainless Steel

Material ~ Copper

Connection for carbon fiber
Heater element

Connection for external
electrical power

19 gauge wire

Spacers

- **Purpose**
 - Control reactivity
 - Separate central heated region
- **Material**
 - Graphite
- **Planned Dimensions**
 - Outer Diameter: 5.9 inch
 - Inner Diameter: 4.9 inch
 - Height: 0.1 – 1 inch

Reflectors

- **Axial Reflectors**
 - Depleted Uranium
 - Be
- **Radial Reflectors**
 - Be blocks from Honeycomb experimental series
- **Intermediate Radial Reflectors**
 - Graphite corner pieces

Experiment Design Summary

- Planet Critical Assembly Machine
- Proof of Concept
- Execution
 - Validate reactivity at room temperature
 - Heat central region to various points, up to 330 C
 - Repeat without YH_2 (i.e. only HEU) in central heated region
 - Compare reactivity effects **at** all temperatures
 - Compare to expected results
- Possible Future Experiments
 - Benchmark quality
 - Highly detailed characterization of all materials
 - Procurement of many new parts, such as Be
 - Effect of poison in the center

MCNP® Rendering of the Central Heated Region

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