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VTR Fuel Design & Analysis Update Presentation

February 2021

Doug Crawford, Douglas L Porter

Changing the World's Energy Future

Idaho National Laboratory

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Idaho National Laboratory
Idaho Falls, Idaho 83415

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SOLVING ENERGY CHALLENGES THROUGH SCIENCE

VTR Fuel Design & Analysis Update

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D. L. Porter, D. C. Crawford, VTR Fuel Design & Analysis

Note: Information regarding site location is **preliminary**. The decision for site location is determined via DOE acquisition processes that have not yet been completed.

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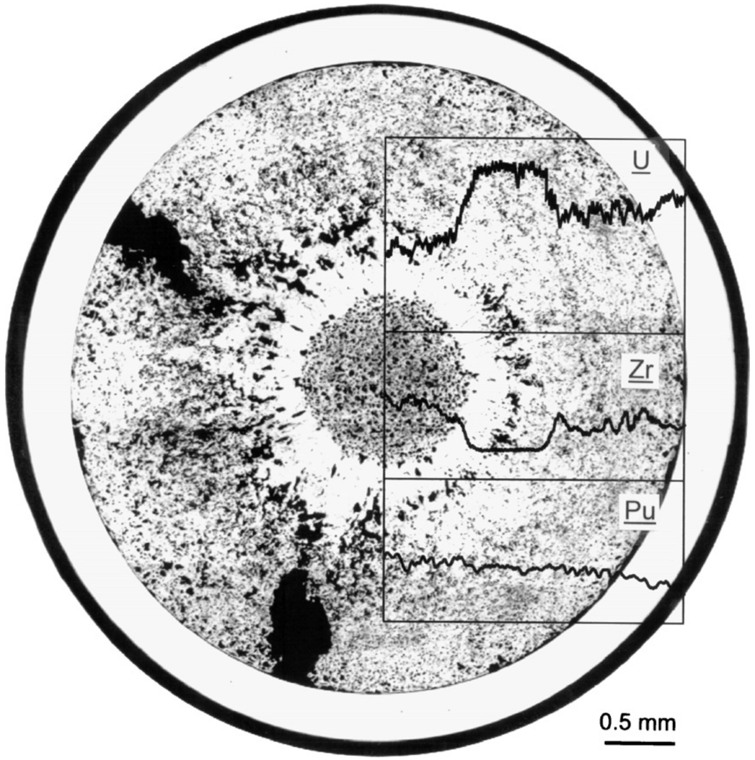
FY 2021 Fuel Design & Analysis Priorities

- Post-appropriation priorities and scope adjusted (somewhat) to align with Project priorities
- Fuel feedstock supply
  - Address accommodation of possible WG Pu feedstock compositions (Ga, impurities)
    - Fuel performance assessment; fabrication & specification experience
  - Support evaluation of potential source materials
- Fuel performance and design analysis
  - U-Pu-Zr-Ga performance analysis
  - As possible, continued progress on BISON metal fuel benchmark cases and sensitivity/uncertainty analysis
- Fuel and in-core assembly component design
  - Support design of interfacing interfacing priorities
  - Make progress on other assembly component conceptual designs, budget permitting
- Other
  - Fuel alloy specification to accommodate WG Pu feedstock
  - HT9 components supplier qualification
  - Fuel performance design basis: HT9 cladding creep and stress rupture updates

Fuel Feedstock Supply

- U-Pu-Zr-Ga assessment: so far, U-Pu-Zr-Ga use appears justifiable, but with uncertainty
  - Experimental work to provide additional data for reducing uncertainties
    - Fuel microstructure (X521 as-fab'd and irr'd characterization)
    - Ga diffusion from fuel into Ga (U-Pu-Zr-Ga/Cladding diffusion couples)
  - Analysis and technical evaluation to clarify uncertainties
    - Thermodynamics-based study to predict phase equilibria and melting temperature impact
    - Assessment of potential impact on fuel constituent migration and solidus temperatures
    - Ga impact on cladding (embrittlement, wastage)
- Pu supply options support
  - Fuel performance assessment of possible impurities from Pu sources
  - Assessment of Pu-239 reduction for increased U-235 enrichment
  - Fuel Performance Design Basis revision for Pu = 10 to 26 wt.%

Y.S. Kim et al. / Journal of Nuclear Materials 359 (2006) 17–28



Fuel Performance and Design Analysis

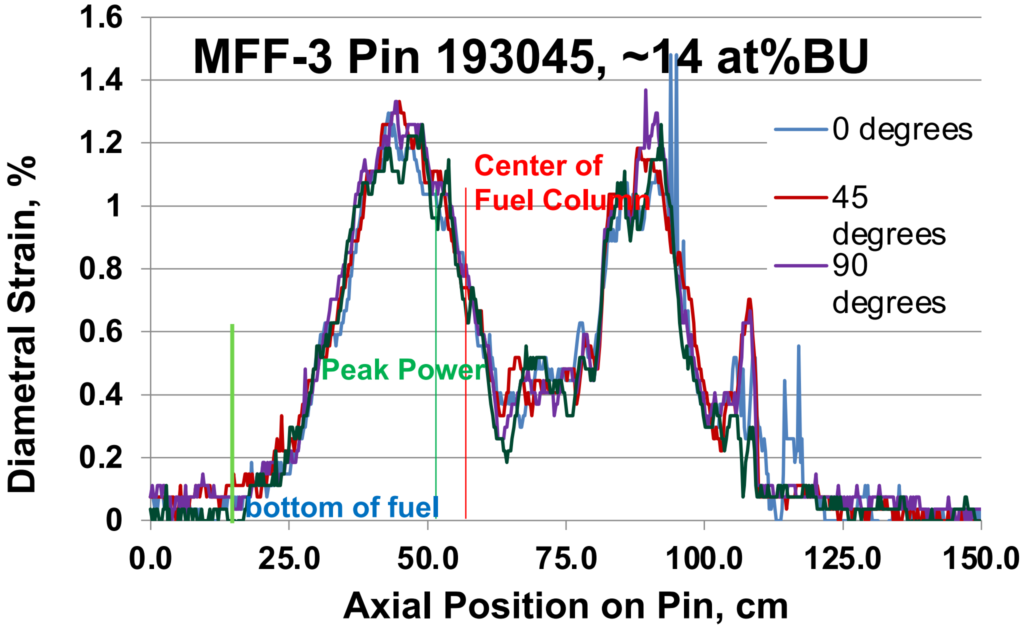
- ORNL work had been continuing adaptation and demonstration of BISON application to VTR fuel
  - Benchmarking cases for X430, X421, IFR-1
  - Sensitivity/Uncertainty analyses
  - Preliminary BISON analyses of VTR to highlight needs for additional work
  - Selected tasks to continue with re-scope
- FY 2021 scope revised to emphasize Ga implications for U-Pu-Zr-Ga
  - ORNL assessment of U-Pu-Zr-Ga fuel performance questions
  - Looking for thermodynamic assessment of phase equilibria and potential impacts to melting temperature, fuel constituent distribution, and Ga migration
  - Include potential impurities from Pu feed, such as Ag and Co, in thermodynamic analyses
  - Expected to continue into FY 2022

Fuel and In-Core Component Design

- Priority in FY 2020 and FY 2021 has been given to evaluation and design of assembly lower nozzles to support core designers determine intended core flow distribution
- When possible, work has progressed to elaborate some details of fuel and in-core assembly conceptual designs
- Remainder of FY 2021 work
  - Continue to support core design and analysis as needed
  - Push forward to elaborate details of assembly conceptual designs, such as
    - Mechanical attachment of HT9 ducts to upper and lower fixtures
    - Fuel assembly grid plates and fuel rod end plugs
    - Attachment of reflector blocks to upper and lower assembly fixtures
    - Additional internal features of shield assemblies, reflector assemblies, and control assemblies
  - Note that we need to know core-wide fast flux distribution to assess fluence on non-fueled components
    - Will allow us to determine which sub-components need to be HT9, for its lower swelling, and which can be 316L

Fuel and Components Specification

- Not much movement, but progress in support of the following:
- Fuel specification
  - Fuel alloy impurity specification, based on ANL evaluation
  - Requested Pu-239 fissile equivalence for other fissile isotopes (U-235, Am-241)
- HT9 components specification (TerraPower)
- Fuel performance design basis: HT9 cladding creep and stress rupture updates
  - Could support eventual increase in burnup limit
    - Reduces Pu requirement
    - Reduces fuel cost
    - Reduces spent fuel and TRU waste



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