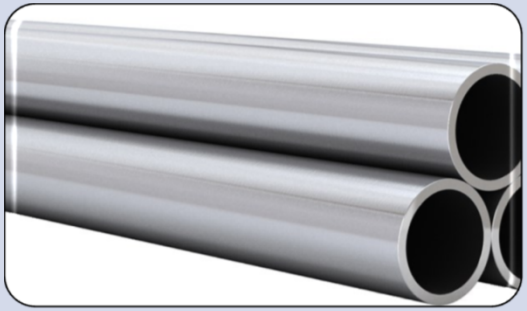
ATF/HBU/IE Fuel Licensing Challenges

EPRI-DOE HBU WS

Joe Donoghue, NRC

March 30, 2022

Near-Term ATF Technologies



Coated Cladding

- A thin chromium-based layer is applied to the cladding outer diameter
- NRR staff have issued Interim Staff Guidance ATF-ISG-2020-01 to support reviews
- Currently awaiting topical reports

Doped Pellets

- UO_2 pellets contain small amounts of added materials that improve performance through larger grain sizes
- Already approved for BWRs. Two fuel vendors have submitted TRs for PWRs.
- No foreseen licensing challenges

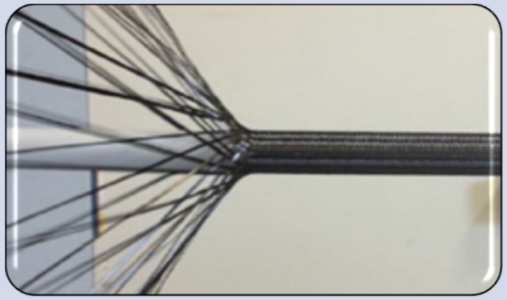
FeCrAl Cladding

- Iron-Chromium-Aluminum based alloy fuel cladding
- Commercialization is a few years away

Longer Term ATF Technologies

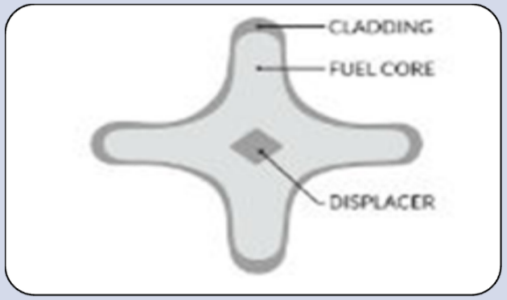
High Density (Uranium Nitride) Pellets

- Fuel made of Uranium Nitride instead of Uranium Dioxide



Silicon Carbide Cladding

- Ceramic composite-woven fibers around a monolithic tube



Extruded Metallic Fuel

- Extruded metallic bar composed of a Zirconium-Uranium matrix within a zirconium alloy cladding

Increased Enrichment and Higher Burnup

Higher Burnup

- Currently limited to 62 gigawatt days per metric ton of Uranium (GWd/MTU) rod-average burnup
- BU limits defined in analysis methods - not in regulation
- Industry goal to reach 75 to 80 GWd/MTU

Increased Enrichment

- Enrichment currently limited to 5 weight percent ^{235}U.
- Industry goal up to 10 weight percent ^{235}U

Higher Burnup

Challenges

- Higher burnup effects - fragmentation, relocation, and dispersal (FFRD)
- Updates to spent fuel storage and transportation requirements
- Potential impact on source term
- HBU Designs may need increased enrichment

Increased Enrichment

Challenges

- 10 CFR 50.68 and 71.55 contain a 5% limit – exemptions may be required – Pursuing rulemaking
- Criticality will need to be evaluated in fabrication, transportation, and storage
- Fuel fabrication facilities originally licensed for 5% – some recently approved to increase enrichment

Future

- Combinations of these concepts are possible (and expected) in future licensing requests
- Applicants need to ensure that proposed design is safe and satisfies regulations

Guidance

Advanced Feature	Available Guidance and Discussion
Chromium-Coated Zirconium Cladding	• ATF-ISG-2020-01, Interim Staff Guidance, Chromium-Coated Zirconium Cladding • Vendor proprietary fuel properties and performance
Doped UO_2 Fuel Pellets	• New guidance not required • GNF, Framatome, and Westinghouse doped UO_2 fuel concepts already NRC approved • Vendor proprietary fuel properties and performance • Application methodology well defined
FeCrAl Cladding	• Technology is not mature enough • GNF proprietary • Is guidance needed for a single-vendor proprietary concept?

Guidance (cont.)

Advanced Feature	Available Guidance and Discussion
Extended Burnup (up to 68 GWd/MTU)	• RG 1.236 CRE/CRD Accidents • DG-1389 AST Radiological • Impacts on fuel properties well characterized • What, if any, further guidance is needed?
Increased ^{235}U Enrichment (Beyond 5.0 wt%)	• 50.68 rulemaking begun • Impacts on fuel properties well characterized • Framatome topical report under review • What, if any, further guidance is needed?
High Burnup (beyond 68 GWd/MTU)	• Data gaps exist • FAST validation identified extend of public empirical database • Vendor proprietary fuel properties and performance databases • What, if any, further guidance is needed?

Guidance (cont.)

Advanced Feature	Available Guidance and Discussion
Fuel Fragmentation and Dispersal	• **Regulatory & guidance implications** • **Vendor proprietary analytical models, methods, and approaches** • **Technical challenges (e.g., size distribution, transport, coolant interaction, and decay heat removal) understood** • **Need to solve technical challenges which would allow fuel dispersal** • **Are planned activities sufficient?**