

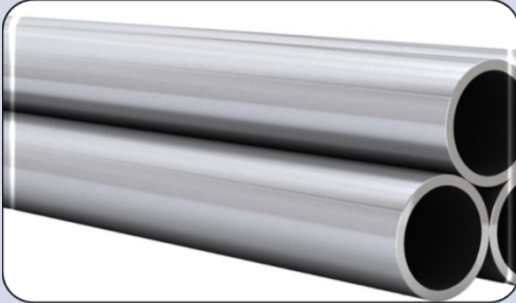
ATF/HBU/IE Fuel Licensing Challenges

EPRI-DOE HBU WS

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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

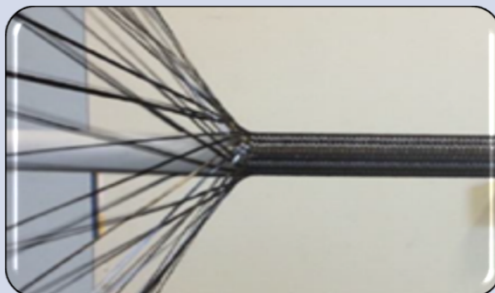
- Iron-Chromium-Aluminum based alloy fuel cladding
- Commercialization is a few years away

Longer Term ATF Technologies



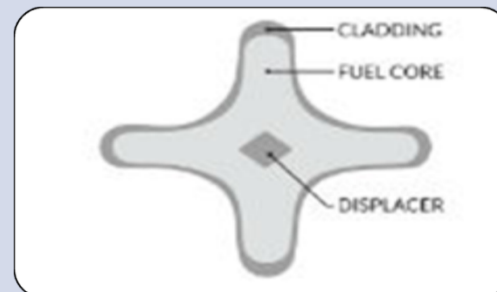
High Density (Uranium Nitride) Pellets

- 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	<ul style="list-style-type: none"> • ATF-ISG-2020-01, Interim Staff Guidance, Chromium-Coated Zirconium Cladding • Vendor proprietary fuel properties and performance
Doped UO₂ Fuel Pellets	<ul style="list-style-type: none"> • New guidance not required • GNF, Framatome, and Westinghouse doped UO₂ fuel concepts already NRC approved • Vendor proprietary fuel properties and performance • Application methodology well defined
FeCrAl Cladding	<ul style="list-style-type: none"> • 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)	<ul style="list-style-type: none"> • 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%)	<ul style="list-style-type: none"> • 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)	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none">• 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?