INL HALEU Capabilities

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Outline

- EBR-II metal uranium product
  - Recast- metal product
  - Small-scale polishing- oxide product

- Aluminum or Zirconium clad HEU fuels
  - Headend treatment (ZIRCEX)
  - Processing (pilot-scale and engineering-scale)
EBR-II Driver fuel processing

- Electrorefiner
  - Uranium, Salt
  - Salt w/TRU+Fission Products + NaCl
- Cathode Processor
  - Zeolite + Glass
  - Salt/Zeolite Blending
- Casting Furnace
  - Zeolite + TRU + Fission Products
- Ceramic Waste Furnace
  - Ceramic Waste Form
- Metal Waste Furnace
  - Metal Waste Form
- Depleted Uranium
- Uranium Product

**Electrorefined uranium dendrite product**

**Cast uranium product ingot**
Pyroprocessing – EBR II Driver Fuel

Spent Driver

- Uranium: 81.2%
- Noble Metals: 12.6%
- Active Metals: 3.6%
- Lanthanides: 2.0%
- Actinides: 0.4%
- Gases: 0.2%
- Halogens: 0.1%

Electrorefined Uranium Ingot

- Uranium: 99.58%
- Noble Metals, 0.42%
- Actinides, 1.1E-6
- Active Metals, 83.0E-9
HALEU EBR-II Metal Feedstock Progress

- HALEU as metal from EBR-II is the nearest term feedstock available to support fast-spectrum advanced reactor concepts
- Processing of EBR-II driver fuel will continue until all driver fuel is processed
- Production of EBR-II HALEU reguli will continue until all EBR-II driver fuel has been treated
  - Operations ramp up to 7 day/wk, 12 hr/day
  - 0.365 MT produced in 2019
  - 2nd furnace available 2020 – 1 MT/year
  - 5 MT forecast to be available by 2024
HALEU EBR-II Oxide Feedstock Demonstration

- Polished EBR-II uranium product suitable for thermal spectrum reactors
- Demonstrated U Polishing in small-scale equipment (using equipment on-hand)
  - Dissolution of EBR II uranium metal regulus
  - Uranium purification from residual fission products by solvent extraction
  - Precipitation of uranium using peroxide process
  - Uranium oxide produced by calcination
U metal regulus → Uranyl Peroxide - $\text{UO}_2(\text{O}_2)\cdot4\text{H}_2\text{O}$ → $\text{UO}_2$ pellets
EBR-II oxide product characteristics

• All metal species except uranium were below analytical detection limits

• Uranium isotopic analysis (same as metal)
  – U-235: 19.77%
  – U-238: 79.5%
  – U-234: 0.18%
  – U-236: 0.55%

• Dose rates (theoretical dose for unirradiated 20% U-235 HALEU)

<table>
<thead>
<tr>
<th></th>
<th>HALEU Regulus</th>
<th>Uranyl Peroxide (UO_4·4H_2O)</th>
<th>Uranium Trioxide (UO_3)</th>
<th>Uranium Oxide</th>
<th>Theoretical Dose At Contact*</th>
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<tbody>
<tr>
<td>Dose rate per Kg</td>
<td>583 mR Hr⁻¹ β⁻</td>
<td>6.8 mR Hr⁻¹ β⁻, γ</td>
<td>2.2 mR Hr⁻¹ β⁻, γ</td>
<td>0.9 mR Hr⁻¹ β⁻, γ</td>
<td>0.053 mR Hr⁻¹ β⁻, 0.908 mR Hr⁻¹ γ</td>
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Dry headend for zirconium or aluminum clad fuels
ZIRCEX Headend Progress

- Pilot plant operational on October 3, 2019
- Zirconium decladding testing initiated (10 completed runs to date)
- 2020 test schedule to include Zr and Al
- Receipt of unirradiated HEU fuel elements was completed in November 2019
Process scale-up

- Design of pilot-scale processing glove box line for clean or lightly irradiated materials - in progress
  - Dissolution/solvent extraction/conversion/waste vitrification
    - EBR-II product (19.7% HALEU)
    - ZIRCEX pilot plant product (unirradiated HEU)
    - Other fuel/orphan materials

- Engineering-scale demonstration conceptual design in progress

- Projected 1-2 MT/yr of HALEU based on EBR-II and ATR recycled fuels
Projected INL HALEU Production Rates

![Graph showing HALEU Production from 2020 to 2035 for EBR II and HZD Production.]
2021 – Planned Activities

• EBR-II
  – Continue processing EBR-II driver fuel
  – Continue to recast previously processed EBR-II uranium product into reguli
  – A total of 1 MT of HALEU reguli will be produced per year

• ZIRCEX
  – Complete testing of Zr and Al simulated fuels
  – Initiate testing of unirradiated HEU fuel
  – Complete design of pilot-scale glovebox line for polishing EBR-II product and ZIRCEX HEU product
  – Complete conceptual design of Hybrid-ZIRCEX Engineering-Scale Demonstration
  – Initiate NEPA (Environmental Assessment) for Hybrid-ZIRCEX Engineering-Scale Demonstration
  – Complete construction of in-can vitrification pilot plant