

SNF Treatment at ANL-W

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Sodium bonded SNF treated to date

- **Approximately 3.0 MTHM of sodium bonded EBR-II fuel has been treated by the electrometallurgical process at ANL-W since 1996.**
- **640 kg heavy metal driver fuel (HEU) has been treated since 1996.**
- **2,400 kg heavy metal blanket fuel (DU) has been treated since 1996.**



Advanced Fuel Cycle Initiative

- **The Advanced Fuel Cycle Initiative (AFCI) is a combination of the Advanced Accelerator Applications (AAA) Program and the EBR-II Spent Fuel Treatment Program.**
- **The major goals of AFCI are to**
 - Reduce the cost of commercial spent nuclear fuel disposal
 - Reclaim the energy value from the spent fuel
- **In FY2004, DOE-NE has directed ANL to focus on treatment of EBR-II driver fuel and technology development activities**



FY04 Technology Focus Areas

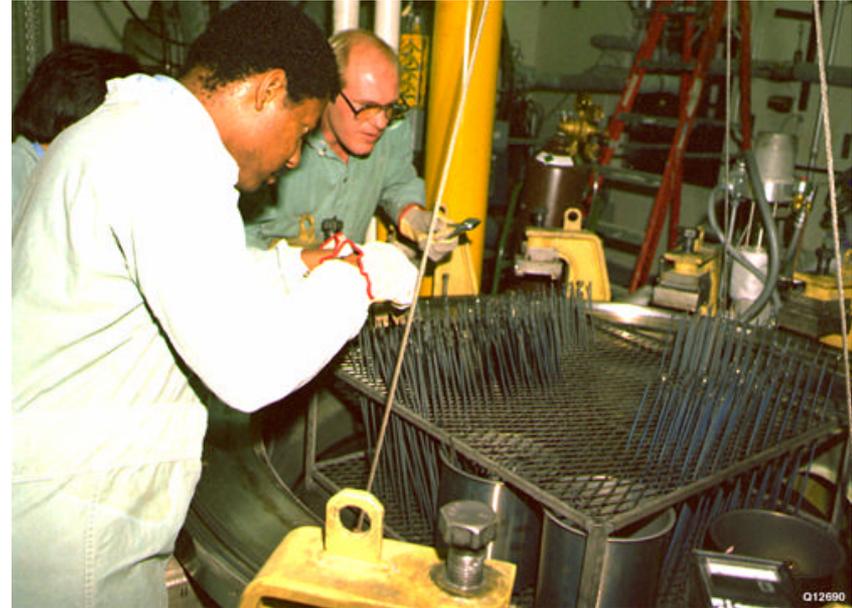
- **Highlights of FY04 technology development activities:**
 - Develop engineering-scale liquid cadmium cathode technology for TRU recovery in Mark V electrorefiner
 - Develop alternative blanket fuel treatment processes
 - Scale-up the ceramic wasteform process
 - Develop DEOX head-end oxide fuel treatment process
 - Continue qualification and testing activities on the metal waste form
 - Upgrade facility systems for radioactive liquid waste handling in FCF and HFEF
 - Continue waste form performance assessment and qualification tasks

Development of EBR-II Blanket Treatment Alternatives

- **Sodium distillation using the Melt Drain Evaporate Carbonate (MEDEC) process - may be feasible due to low burnup/swelling**
- **Sodium removal followed by fuel melting to improve safeguards for disposal**
- **High throughput electrorefining**
 - Planar electrode electrorefiner development
 - Next generation anode basket

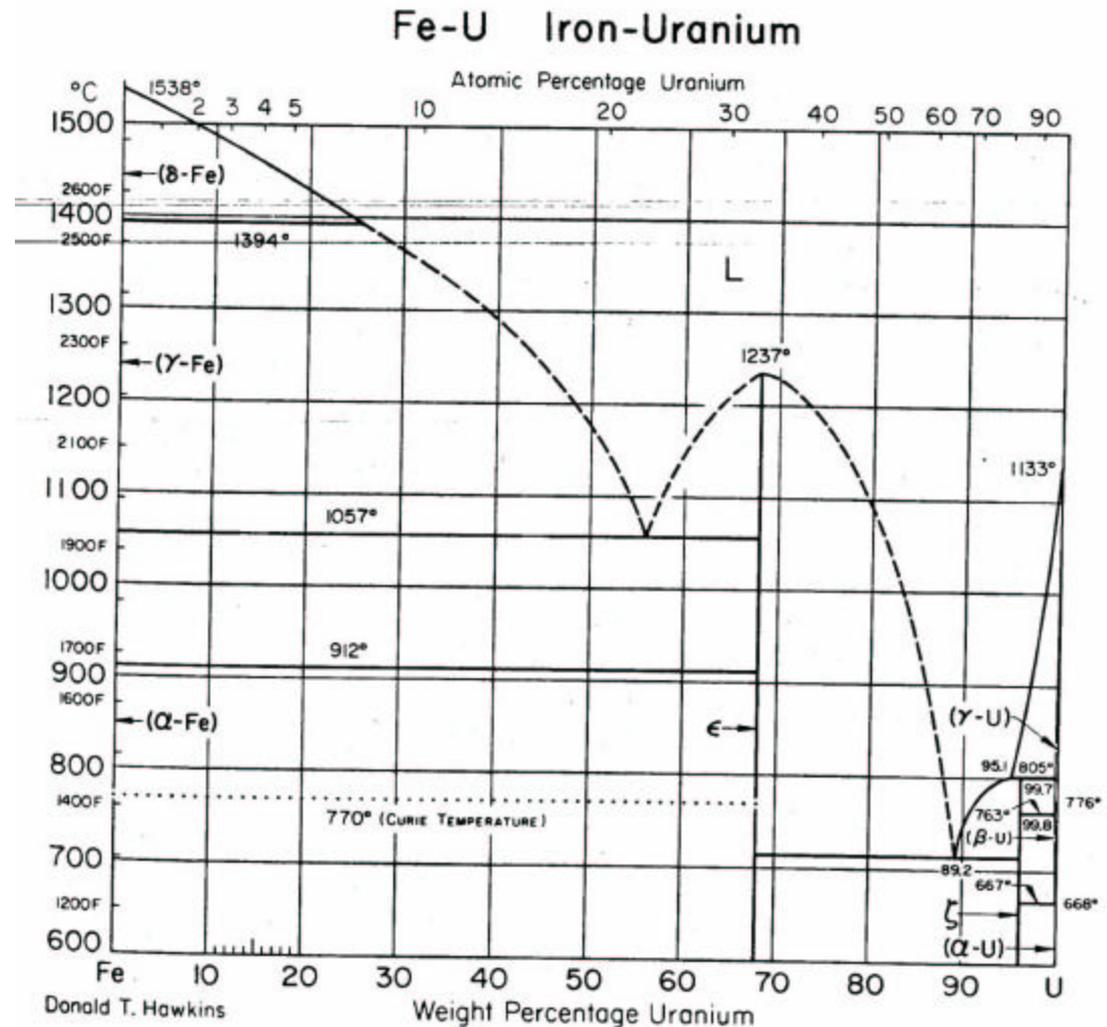
ANL's MEDEC Experience

- **MEDEC (Melt-Drain- Evaporate- Carbonate) technology was developed in the 1980s for sodium removal. This process is based on the evaporative removal of sodium at elevated temperature, reduced pressure, 650°C, 0.2 Torr.**
- **In 2000-2003 DOE-EM provided funding to evaluate the MEDEC process as a treatment approach for 34 MTHM of Fermi blanket fuel.**
- **Tests were completed on unirradiated Fermi and irradiated EBR-II fuel. Feasibility shown for Fermi blanket.**



Melt and Blend

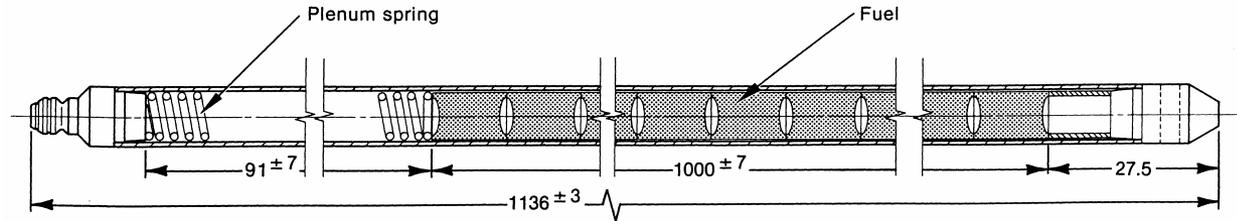
- EBR-II blanket fuel is uranium metal clad with stainless steel. Should be able to melt fuel at ~ 1400 °C.
- Remove sodium from fuel using MEDEC process or use integrated sodium treatment step.
- A “diluent” could be added to the melt to reduce the overall concentration of plutonium in the fuel.



Head-End Oxide Treatment

- **BR3 fuel (4 runs)**

- UO_2 LWR fuel
- Zircaloy-4 cladding
- Irradiated in Belgium Reactor-3 (BR3)
- Average burn-up of 4.5 at%
- 25-yr decay



All dimensions in mm

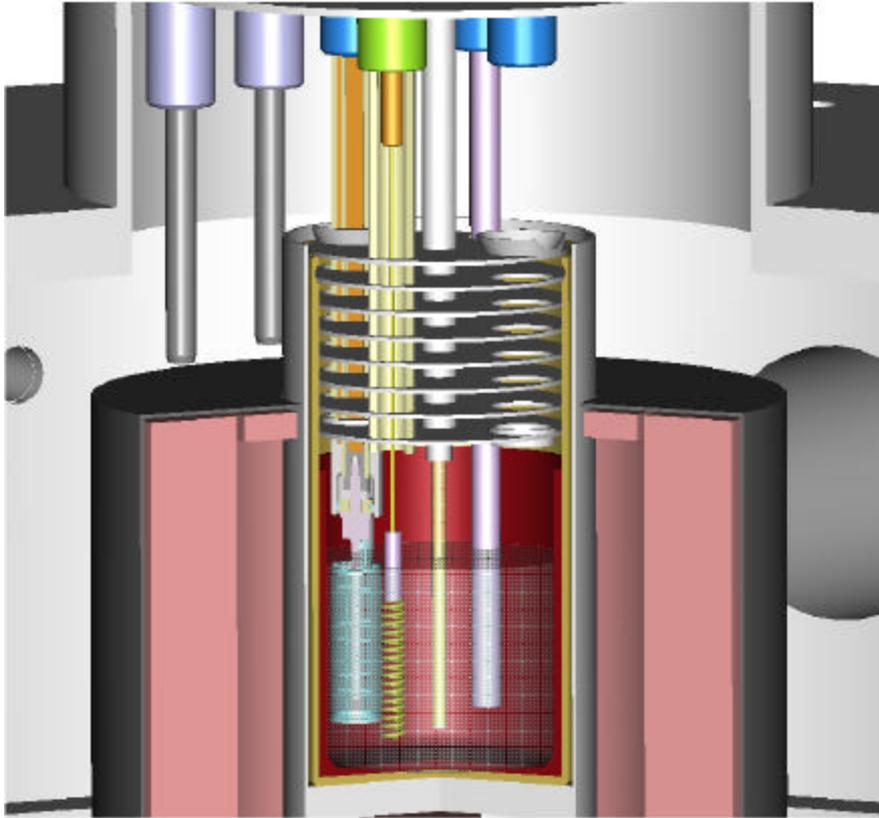


Cladding

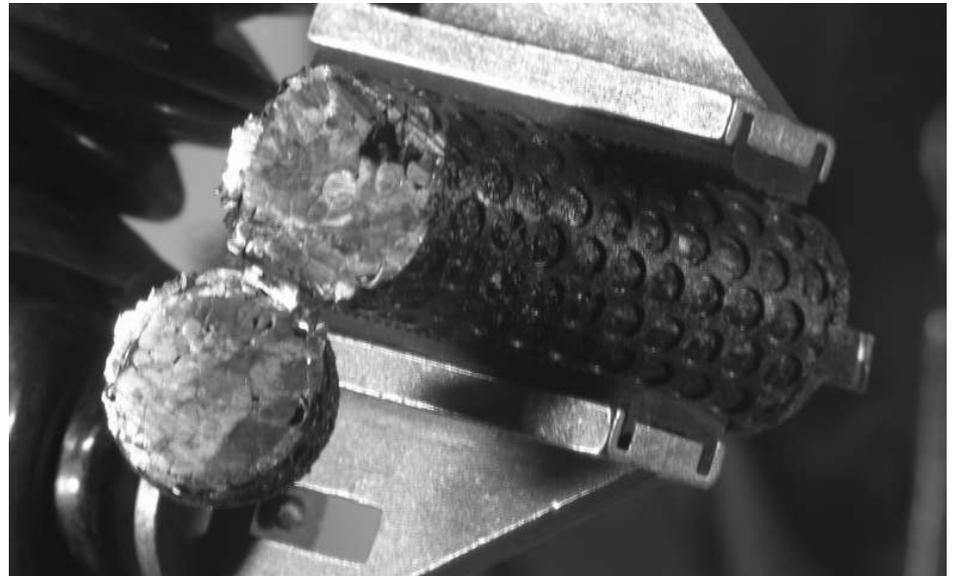


Fuel

Lab-Scale PYROX Test Equipment — HFDA



Hot Fuel Dissolution Apparatus



Declad and Oxidation (DEOX) Development

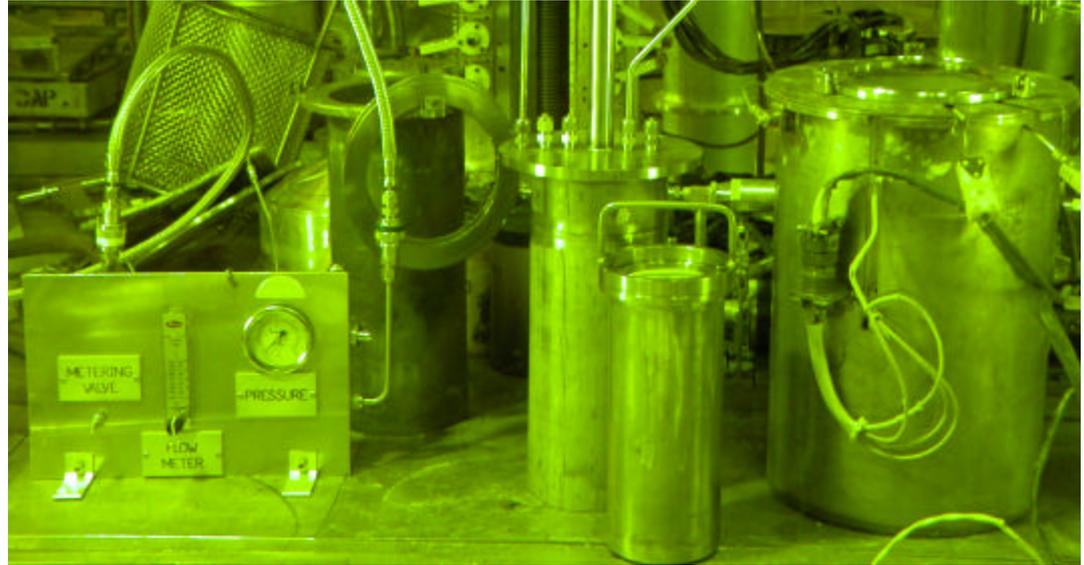
- Demonstrate separation of cladding from spent oxide fuel via reaction: $3\text{UO}_2 + \text{O}_2(\text{g}) = \text{U}_3\text{O}_8$
 - Results in ~30% Increase in Volume
- Produce at least 90% of particles between $45\ \mu\text{m}$ and 4 mm to assist in downstream processing (PYROX or UREX+)
- Study the behavior of fission product (Se, Tc, Ru, Te, I, and Cs) off-gases during the DEOX cycle
- Determine the extent of U_3O_8 oxidation
- Determine process conditions to minimize reaction of zircaloy



DEOX Test Apparatus

DEOX Status

- **FY04 to date:**
 - Completed out-of-cell equipment qualification and HFEF modifications
 - Transferred equipment and initiated in-cell qualification in HFEF.
 - First test with SNF to duplicate literature looked promising. Analyses pending.



DEOX Apparatus Installed in HFEF



BR-3 Test Material in HFEF

Ceramic Waste Form Development

- **Development of ceramic waste process has progressed from laboratory-scale tests to repository-scale (140 kg, 20.4-in diameter).**
- **The transition from Hot Isostatic Press-based waste form to Pressureless Consolidation-based waste form has been accomplished.**
- **A finite element model has been developed to assist in developing process cycles and predicting waste form characteristics.**



Ceramic Waste Form Before and After Pressureless Consolidation

Metallic Waste Form Testing

- **Seven Tests Performed in FY03**
 - Support parameter development of process cycle:
 - *Sodium oxidation (plenum Na by iron chloride)*
 - *Salt distillation*
 - *Metal consolidation*
 - Materials compatibility is acceptable
- **FY04 Highlights**
 - Complete the installation of new induction coil in prototype furnace
 - Verify equivalency of prototype and production furnaces
 - Continue process qualification in prototype furnace
 - Produce 5 qualification ingots with fixed operating parameters to determine product consistency



Ongoing Interactions

- **ANL is supporting a DOE/NE-40 task team which is identifying and analyzing options for managing DOE-NE fuel currently stored in DOE-EM facilities (EBR-II, ATR, HFIR, university reactors, NIST fuel).**
- **Transfer of FFTF sodium bonded SNF to ANL-W for electrometallurgical treatment is being covered by the FFTF Closure Project contract currently up for bid.**