Review of Advanced Fuel Cycle-Related Activities at ORNL

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ORNL Activities Supporting GNEP

The Oak Ridge National Laboratory (ORNL) provides basic research and engineering expertise to the Advanced Fuel Cycle Program, now known as the Global Nuclear Energy Partnership (GNEP) program

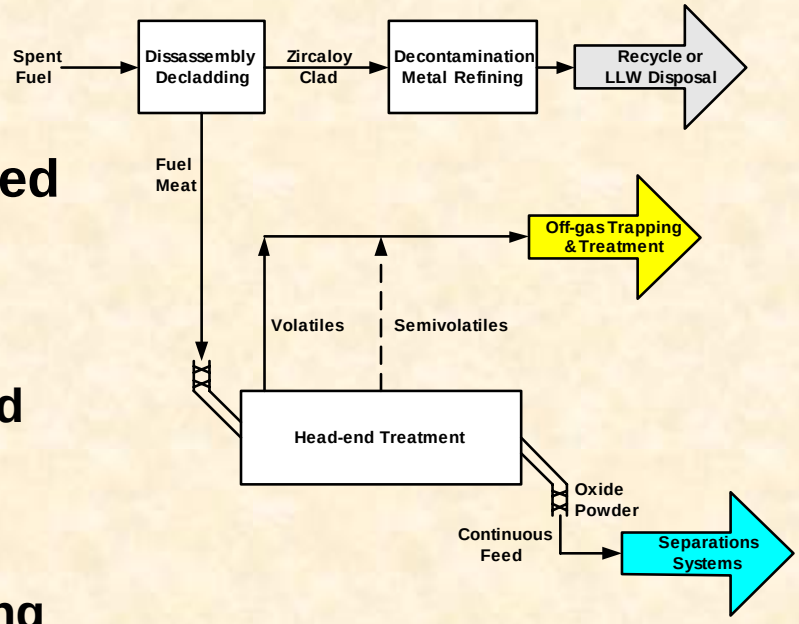
- **Laboratory-scale R&D**
- **Bench-scale process development and demonstration**
- **Process design support for Engineering- or Commercial-scale plants**

Research, Development and Demonstration Activities

- **Provide basic information on process chemistry**
- **Activities currently concentrated on**
  - **Advanced voloxidation**
  - **Testing of UREX+1a and UREX+3 processes**
  - **Separation of lanthanides from trivalent actinides**
  - **Co-conversion of recovered TRU to oxides**
  - **Fabrication of transmutation fuels**

Voloxidation

- **Standard voloxidation is designed for tritium removal, but has other benefits**
  - **Separates a large fraction of the fuel from clad**
  - **Removes significant fractions of other volatiles**
    - **I, ^{14}C, Kr, Xe**
  - **Improves dissolution rate of fuel**
- **Advanced voloxidation being developed to**
  - **Remove ^{3}H as before**
  - **Remove all the other volatiles**
  - **Remove semivolatiles including Mo and Tc**
    - **Problematic in the separations systems**
  - **Improve separation of fuel from cladding**
    - **Goal to promote zirconium recycle and eliminate TRU losses to cladding**



Hot-Cell Testing of UREX+ Processes

- **Key aspects being tested using spent Dresden BWR fuel**
- **Sheared fuel will be voloxidized to remove volatiles**
  - **May convert to UO_3 in an advanced voloxidation cycle**
- **Characterization of low acid dissolution of fuel powder**
- **UREX+1a flowsheet tests, with improvements to**
  - **Eliminate potential hydrolysis problems**
  - **Reduce need for added complexing agents (high acidity)**
  - **Enable process control with on-line spectrophotometric analysis**
- **Raffinate streams to be further tested in TALSPEAK process**

TALSPEAK Process Optimization

- **TALSPEAK=Trivalent Actinide-Lanthanide Separations by Phosphorus-reagent Extraction from Aqueous Komplexes**
- **Comparison of base-line process with alkaline-side separation**
  - **DTPA aqueous complexant–HDEHP extractant**
  - **Hydroxide precipitation–selective bicarbonate dissolution of Am**
- **Small batch of Am-Cm-RE oxide to be produced for use in test fuel/target fabrication studies**

Uranium and U/TRU Co-conversion

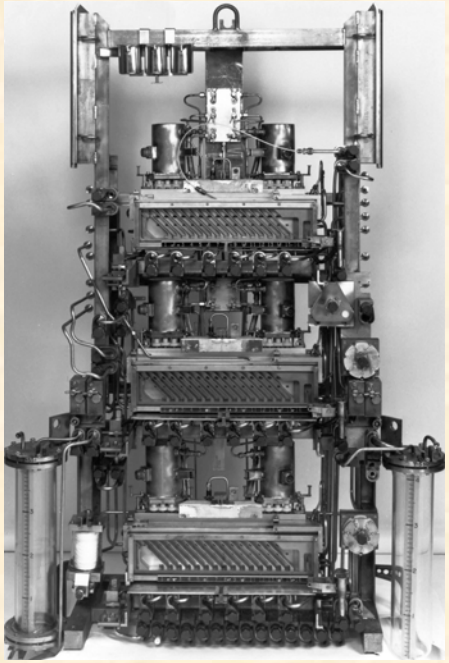
- **Denitration of product streams**
  - **Chemistry well understood for U**
  - **Tests with TRU being made to compare product characteristics**
- **Process equipment design and scale-up**
  - **Testing in rotary calciner**
  - **Off-gas scrubber test**
- **Investigation of**
  - **Pellet fabrication from U/TRU powder pressing and sintering**
  - **Sphere-pac fuel forms**

Bench-Scale Process Demonstration

- **Address remaining development needs of the GNEP program**
  - **Key steps of Ln-TRU separations must be established**
  - **Proof of robust separations through repeated successful tests**
  - **Fabrication of TRU-bearing test targets**
- **Estimated scale to obtain sufficient material for testing**
  - **20 kg/yr of SNF**

Integrated Spent Fuel Separations and Transmutation Fuel (Target) Fabrication

- **All steps of spent fuel processing, up to and including fabrication of transmutation fuel, will be demonstrated in a coupled end-to-end (CETE) operating mode**
  - **Spent fuel receipt and examination**
  - **Fuel disassembly and chopping**
  - **Voloxidation (volatile fission product removal)**
  - **Dissolution**
  - **Separations based on UREX+ suite of processes**
  - **Waste conversion and solidification**
  - **Product co-conversion**
    - **Transuranium actinides**
  - **Fabrication of transmutation fuels/targets**
    - **Pellet fabrication or sphere pac**



Support for Full-Scale Deployment

- **Dissolver system equipment selection and design**
- **Improved solvent extraction modeling**
- **Contactor design and testing**
- **Off-gas treatment system design**
- **Development of coordinated waste disposition strategy**
  - **Pathways toward optimization of costs**

Backup Slides

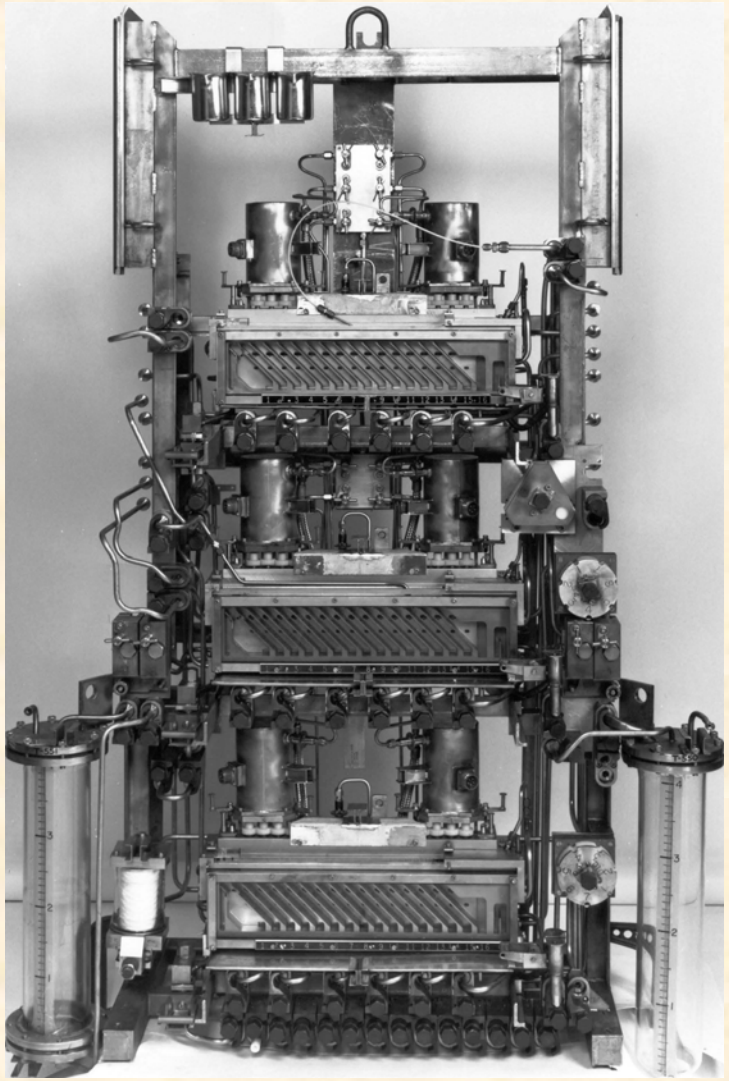
Suite of UREX+ Processes

Process	*Prod #1*	*Prod #2*	*Prod #3*	*Prod #4*	*Prod #5*	*Prod #6*	*Prod #7*
UREX+1	**U**	**Tc**	**Cs/Sr**	**TRU+Ln**	**FP**		
UREX+1a	**U**	**Tc**	**Cs/Sr**	**TRU**	**Ln + FP**		
UREX+2	**U**	**Tc**	**Cs/Sr**	**Pu+Np**	**Am+Cm+Ln**	**FP**	
UREX+3	**U**	**Tc**	**Cs/Sr**	**Pu+Np**	**Am+Cm**	**Ln + FP**	
UREX+4	**U**	**Tc**	**Cs/Sr**	**Pu+Np**	**Am**	**Cm**	**Ln + FP**

Notes: (1) In all cases, iodine is removed as an off-gas from the dissolution process.
(2) Processes are designed for the generation of no liquid high-level wastes.

U: uranium (removed in order to reduce the mass and volume of high-level waste)
Tc: technetium (long-lived fission product, prime contributor to long-term dose at Yucca Mountain)
Cs/Sr: cesium and strontium (primary short-term heat generators; repository impact)
TRU: transuranic elements (Pu: plutonium, Np: neptunium, Am: americium, Cm: curium)
Ln: lanthanide (rare earth) fission products
FP: fission products other than cesium, strontium, technetium, iodine, and the lanthanides

Solvent Extraction Contactor Rack



- **Three 16-stage mixer-settlers (extraction, partition, strip)**
- **Modular rack (3 x 6 ft)**
- **Feed solution is metered from in-cell rack tanks**
- **Reagents added from metering tanks located in the room above**
- **Solutions drain from the contactors by gravity to tanks located below the floor**