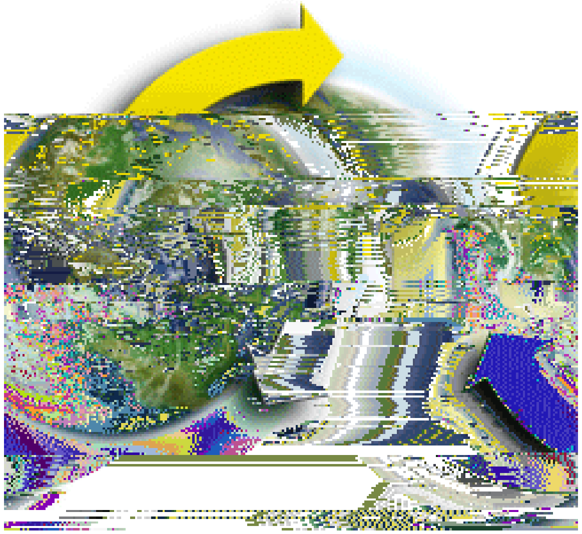


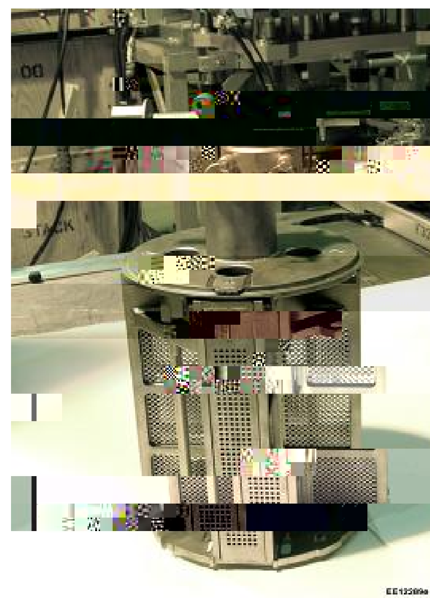
AFCI Separations Activities

R. T. Jubin

Separations Campaign Program Overview

Â **Major program elements**

- Advanced aqueous separations
- Advanced electrochemical separations
- Process equipment scale-up and development
- Off-gas treatment
- Process control and monitoring
- Process modeling and simulation
- EBR-II spent fuel treatment
- Separations regulatory and safety crosscut



Separations Campaign FY-08 Major Accomplishments

- Revised campaign research strategy for aqueous processing
  - De-emphasize repetitive testing of separation process at lab-scale using small amounts of used nuclear fuel
  - Focus on head-end operations
    - Voloxidation to separate tritium
    - Off-gas capture and immobilization of ^{129}I, ^{85}Kr (and Xe), ^{3}H, ^{14}C
  - Demonstrate product conversion using modified direct denitration
  - Transition development activities from laboratory testing to engineering development
    - Incorporate industry input into campaign development activities
    - Increase Technology Readiness Levels (TRL's) > 6
    - Incorporate solvent recycle effects into testing
  - Integrate Waste Form development with Separations development

Introduction to the CETE Demonstration

Â **Develop/Demonstrate Advanced Recycling Technologies**

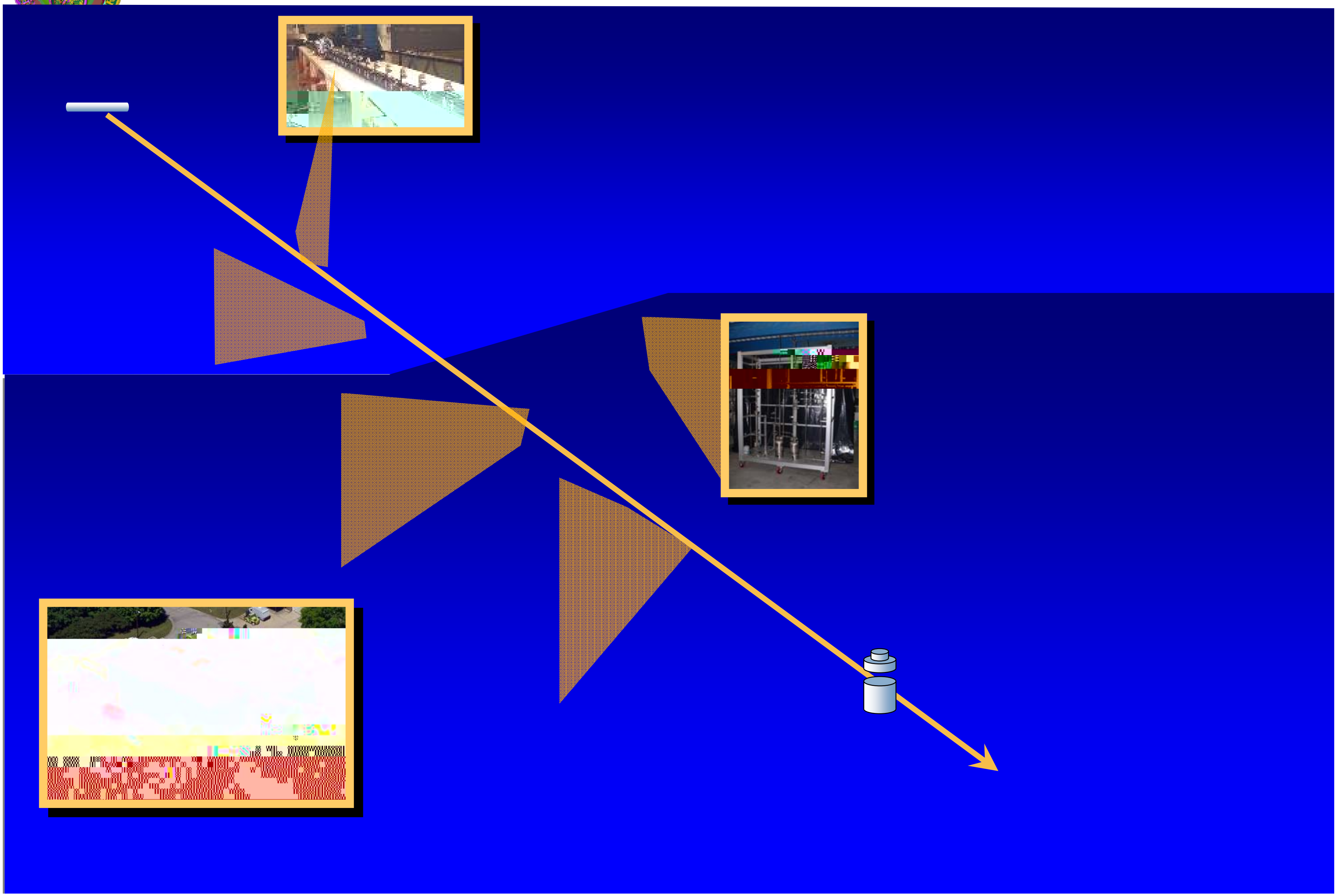
Â **Multiple process runs ~ 5 - 10 kgs/yr of SNF**

Â **Identify and Resolve Scientific & Technical Uncertainties**

- Interfacial Issues
- Process Robustness

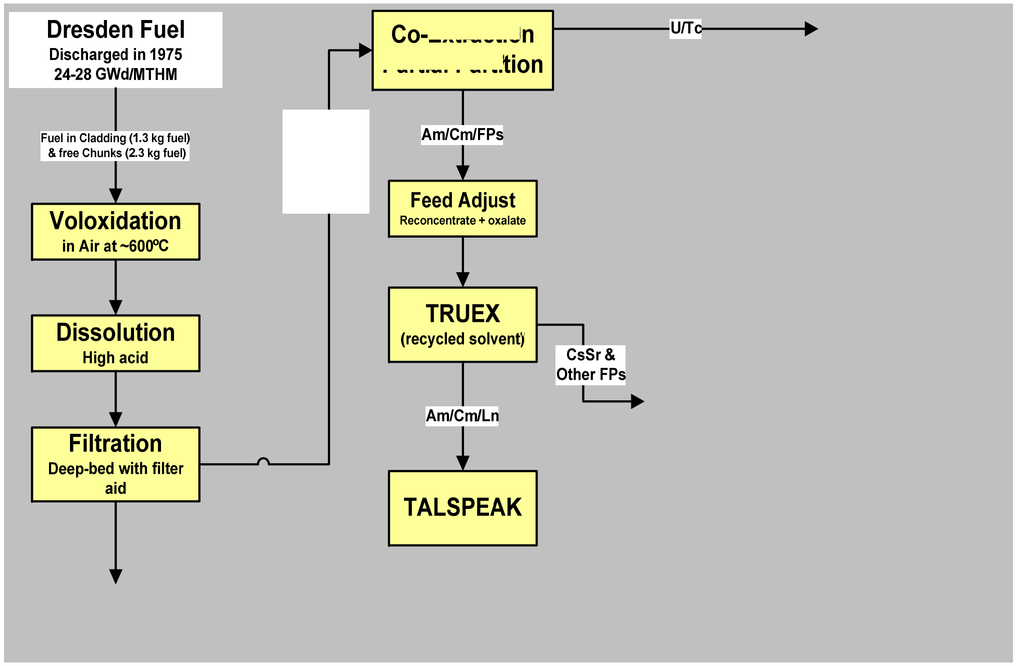
Â **bf 0 2f5tify andsolve Sci1141 0 632 cs.8entific & Tation**

Coupled-End-to-End Demonstration Overview



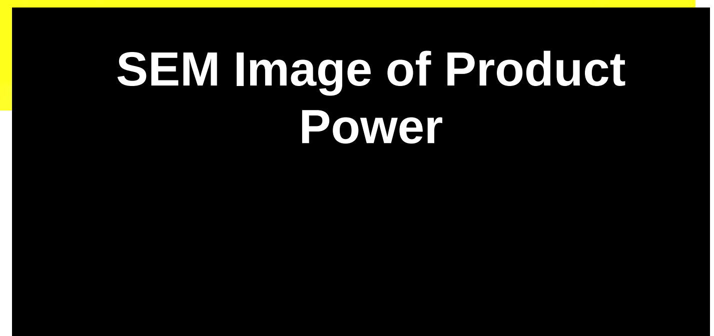
Highlights and Lessons Learned from CETE Run 1

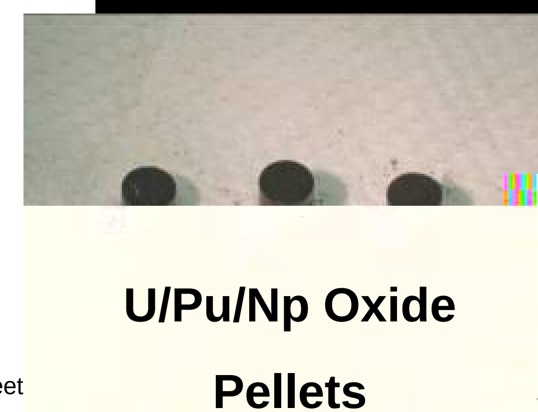
- **Flowsheet Demonstration**
  - Partial partitioning of a U-Pu-Np Product: *No separated Pu*
  - TRUEX-TALSPEAK for Minor Actinide Separation
  - FPEX for Cs/Sr Separation
- **Converted U-Pu-Np and U by Modified Direct Denitration**
- **Demonstrated Fabrication U-Pu-Np co-converted product to pellets.**



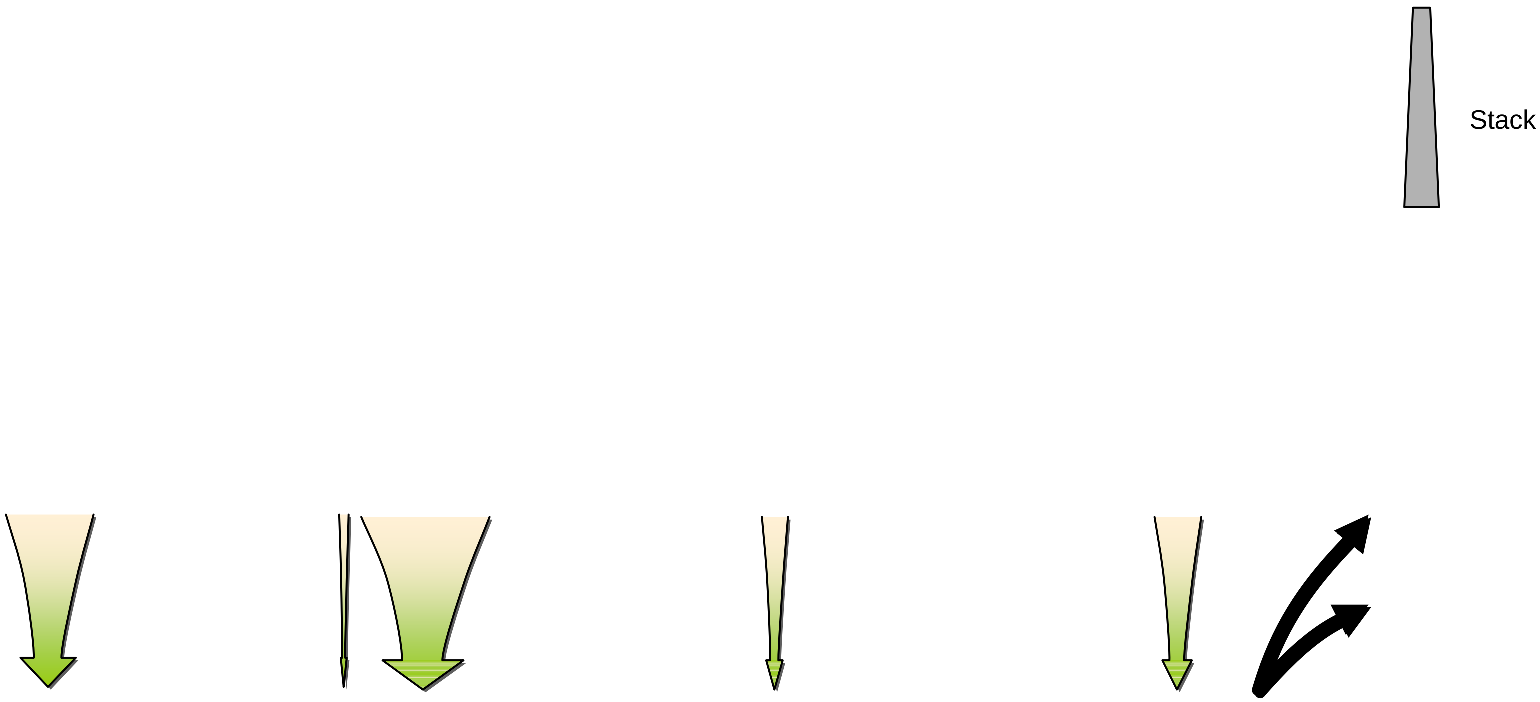
Product Conversions

- **Modified Direct Denitration shows promise for simplifying the interface between separation and fuel fabrication.**
- **Produces a powder with good ceramic properties for pellet fabrication.**
- **Further R&D required**
  - **Process development**
  - **Scaleup**
  - **Qualifying the ceramic product**





Simple Reprocessing Demonstration
(Mass Basis: 1 kg SNF; 55 GWD/MTIHM; 5 year Cooling)



Generic Head-End Off-Gas Treatment Concept

Shear | **Voloxidizer** | **Dissolver**

HTO

FY 09 CETE Based Tests (ORNL)

Â **Hot Integrated Off-gas capture tests on the Voloxidation and Dissolver Off-Gas streams**

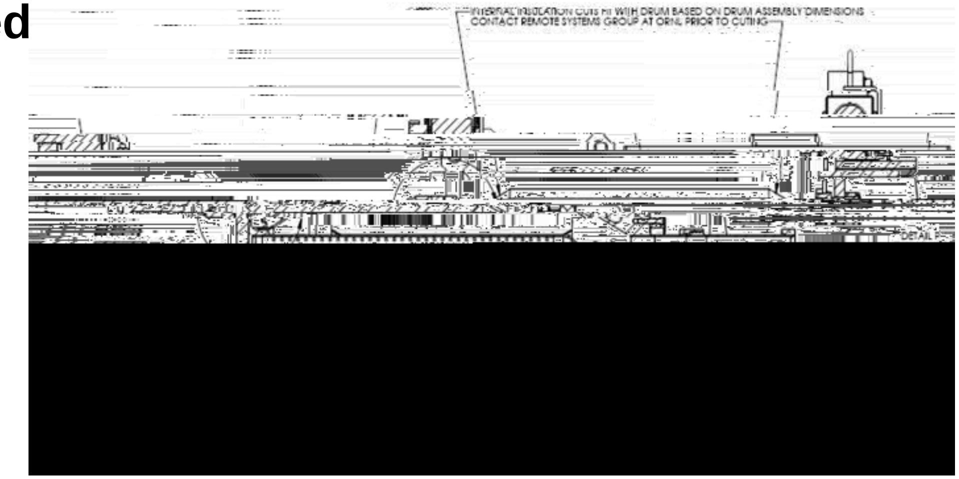
- Objectives
  - *Close volatile component material balances*
    - Voloxidation
    - Dissolution
      - *Analysis for residual iodine in dissolver solution*
    - Shearing of full length fuel – Run 3 or later
  - *Understand impacts of head-end processing conditions on volatile component releases*
  - *Determine capture process interactions*

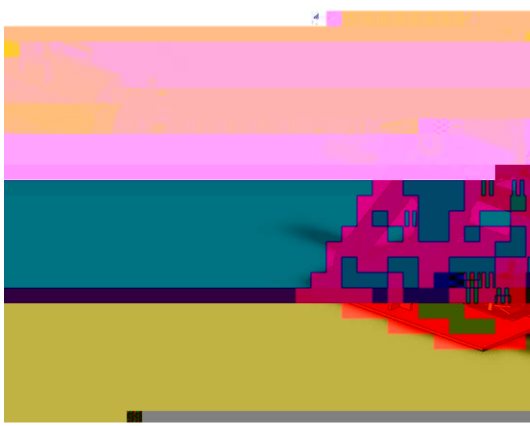
Voloxidation Run 2—Plan and Status

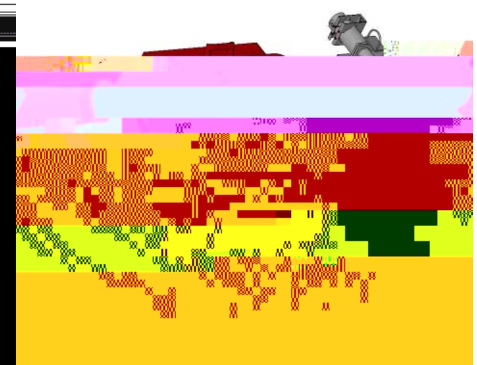
- **Voloxidation processing for Run 2 was planned as three batches**
  - Batch sizes of 1 to 2 kg of spent fuel
  - Total production of at least 5 kg to support separations activities
  - Different conditions were planned for each batch to obtain information on reaction properties and subseque

Small Scale Voloxidation

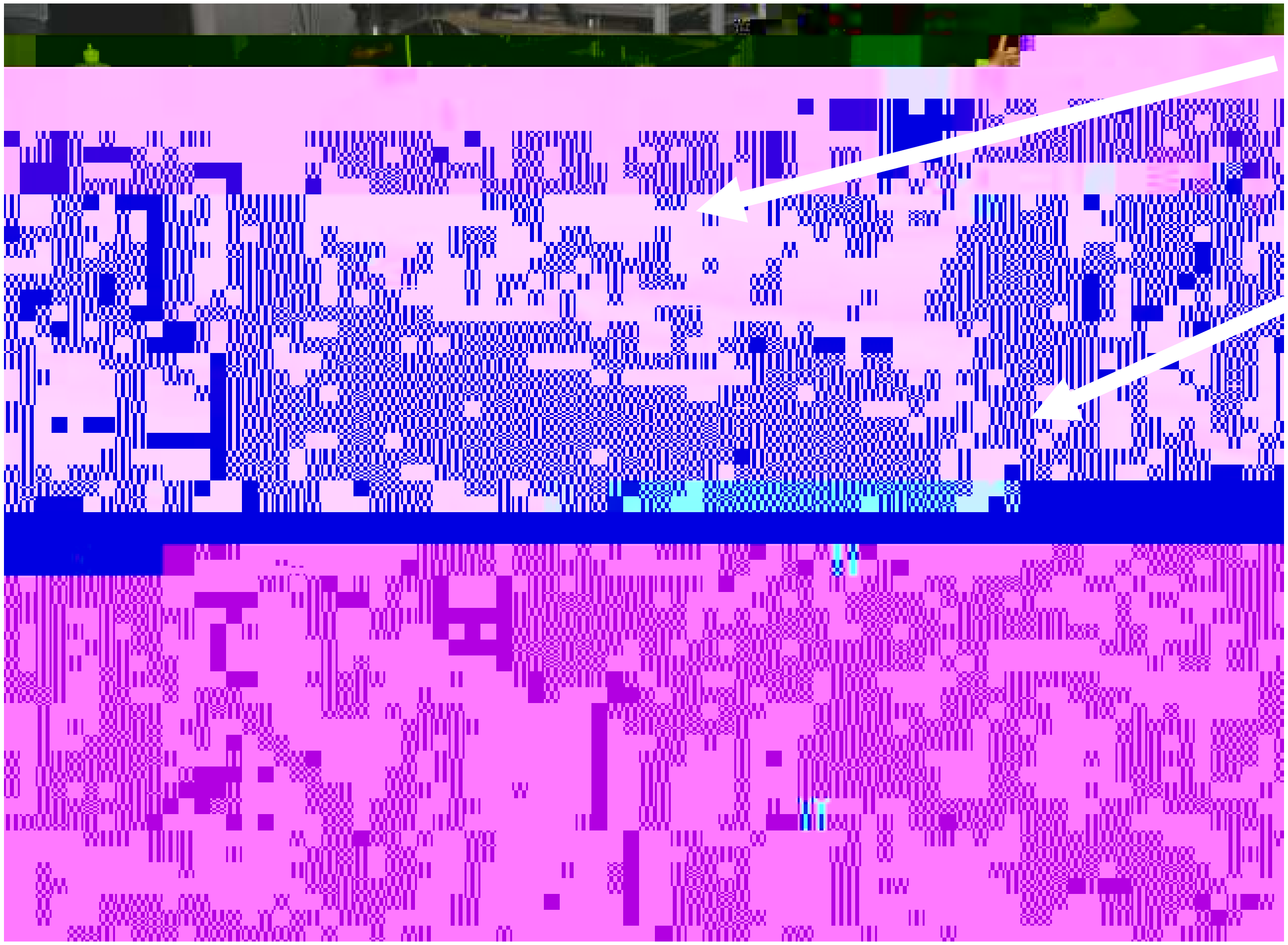
- **Most of the retort tube is enveloped by the furnace**
- **Rotating tube**
- **Variable operating environment**
- **Removable Hulls basket**
- **Powder can integrated into design**
- **Tilting platform can force material into hotter zones**







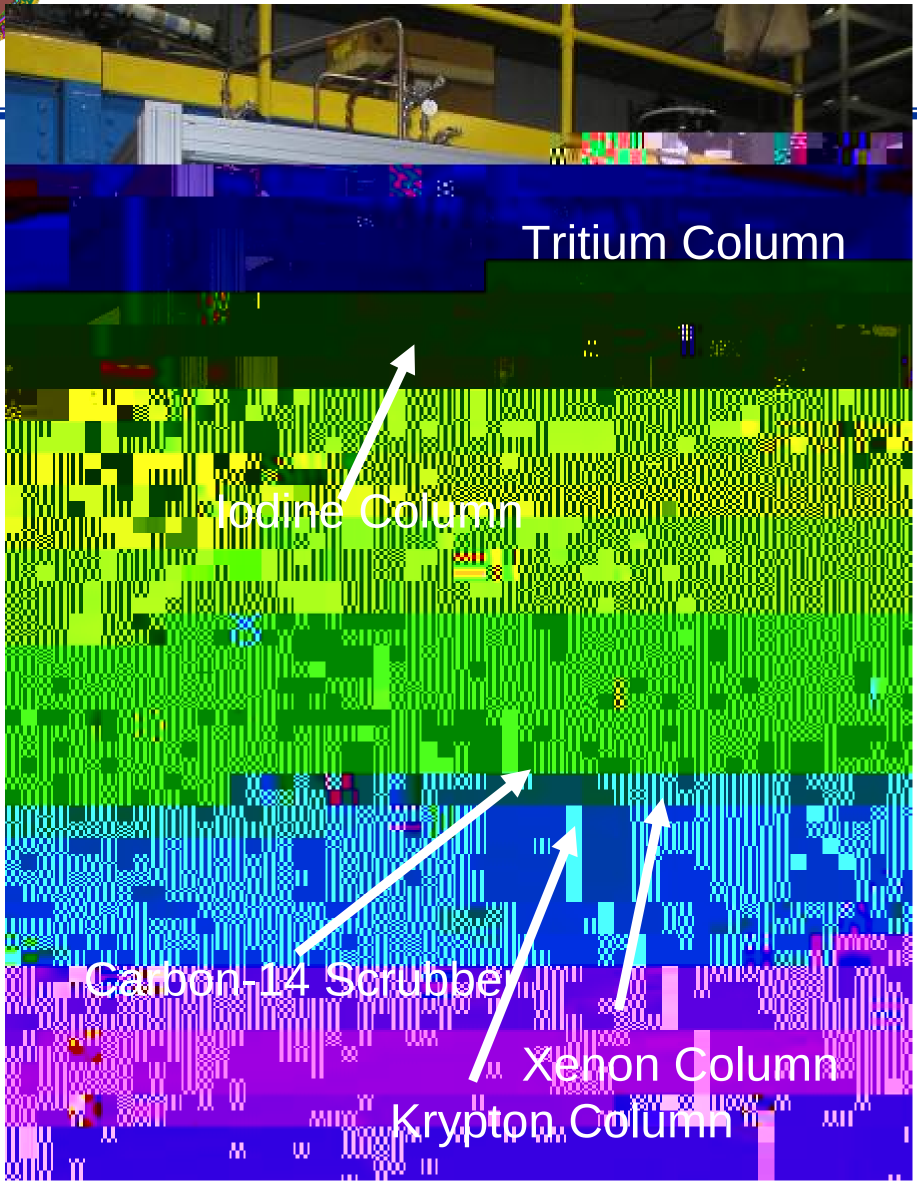
Voloxidation

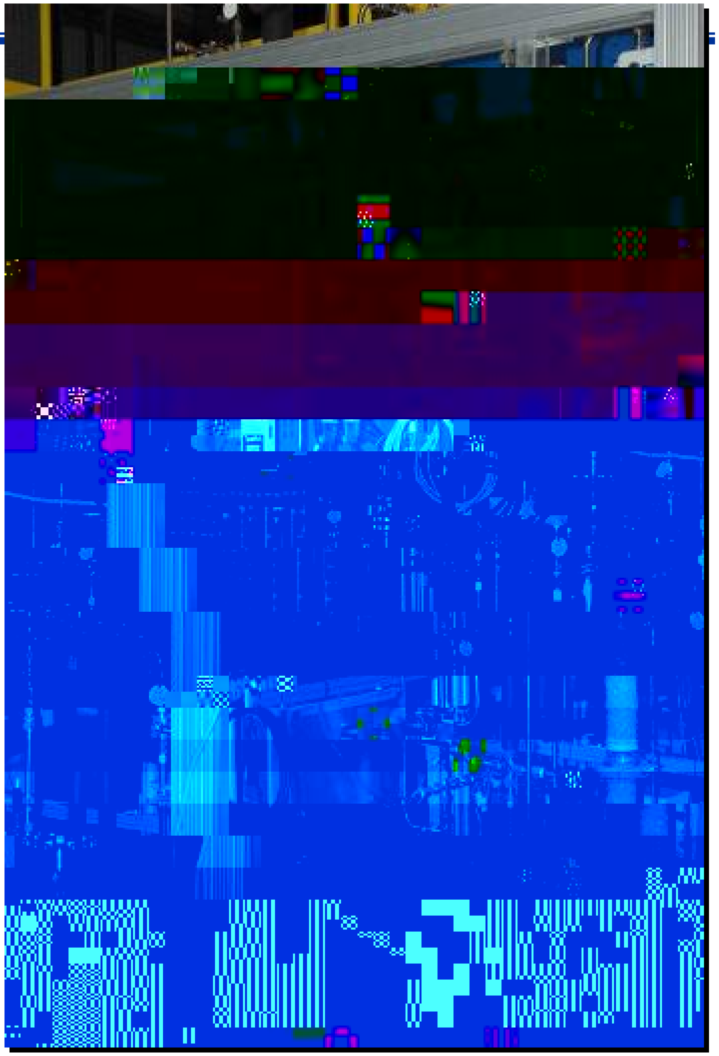


Rotary Kiln w/ Heater in Place

Product Canister

Voloxidizer Off-Gas Rack





Voloxidation Run 2—Batch 1

- **First batch was comprised of Surry-2 fuel**
  - Initial enrichment 3.11%
  - Burnup: 36 GWd/MT heavy metal
  - Cooling time: 27 years (di

Run 2—Batch 1—Part A
O_2 Concentration, Air Flow, and Temperatures

Summary of INL Off-Gas Work

- **FY08: Initiated bench-scale iodine capture studies using nonradioactive constituents**

- **FY09: Continue iodine capture work:**
  - Use commercial sorbent IONEX Type Ag 900
  - Determine DFs under varying conditions (iodine concentration, co-constituents, temperature, residence times)
    - *Dissolver off-gas may contain iodine at ~10 ppm*
    - *Combined vessel off-gas may contain iodine at ~10 ppb*
  - Determine sorbent capacity

Summary of INL Off-Gas Work

- **FY09: Install additional sorption columns for water vapor, CO_2 and Xe (ambient temperature operations)**
  - An integrated bench-scale treatment unit
  - Currently plan to run with nonradioactive constituents
  - Establish baseline capture of water vapor, CO_2 and Xe on commercial adsorbents
  - Test alternative sorbents
  - Design Kr capture system, which may be added in future

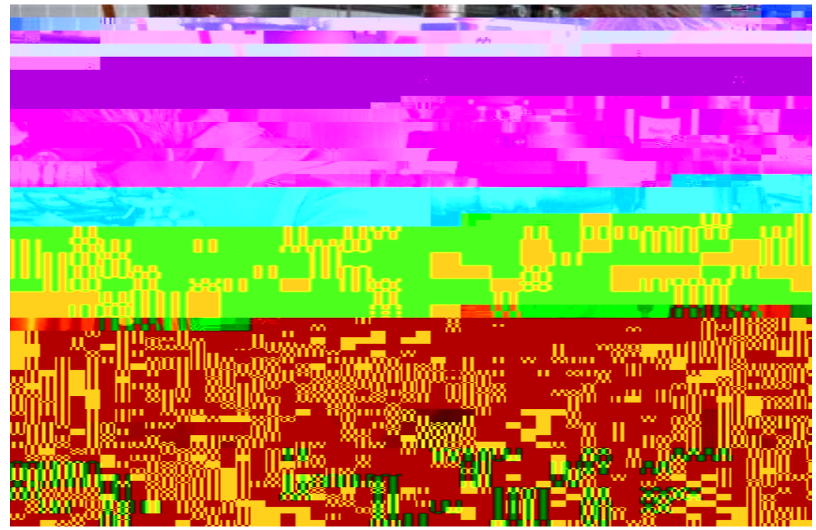
Materials for Iodine Waste Streams - FY09 Plans at SNL

- **Sorption of I_2 gas into traps for encapsulants**
  - Low-temperature glasses
  - Alternative waste forms
- **Primary focus will be on “standard” iodine loaded AgZ materials from ORNL and INL surrogate studies and CETE Hot tests**
  - Retention of iodine
- **Alternate sorbents or recovery operations to produce better waste forms**

Commercial Centrifugal Contactor Testing at the INL in 2008

Â **Testing of remotely operable/maintainable 5-cm contactors**

Â **Design of remotely operable/maintainable “production” scale 12.5-cm contactors**

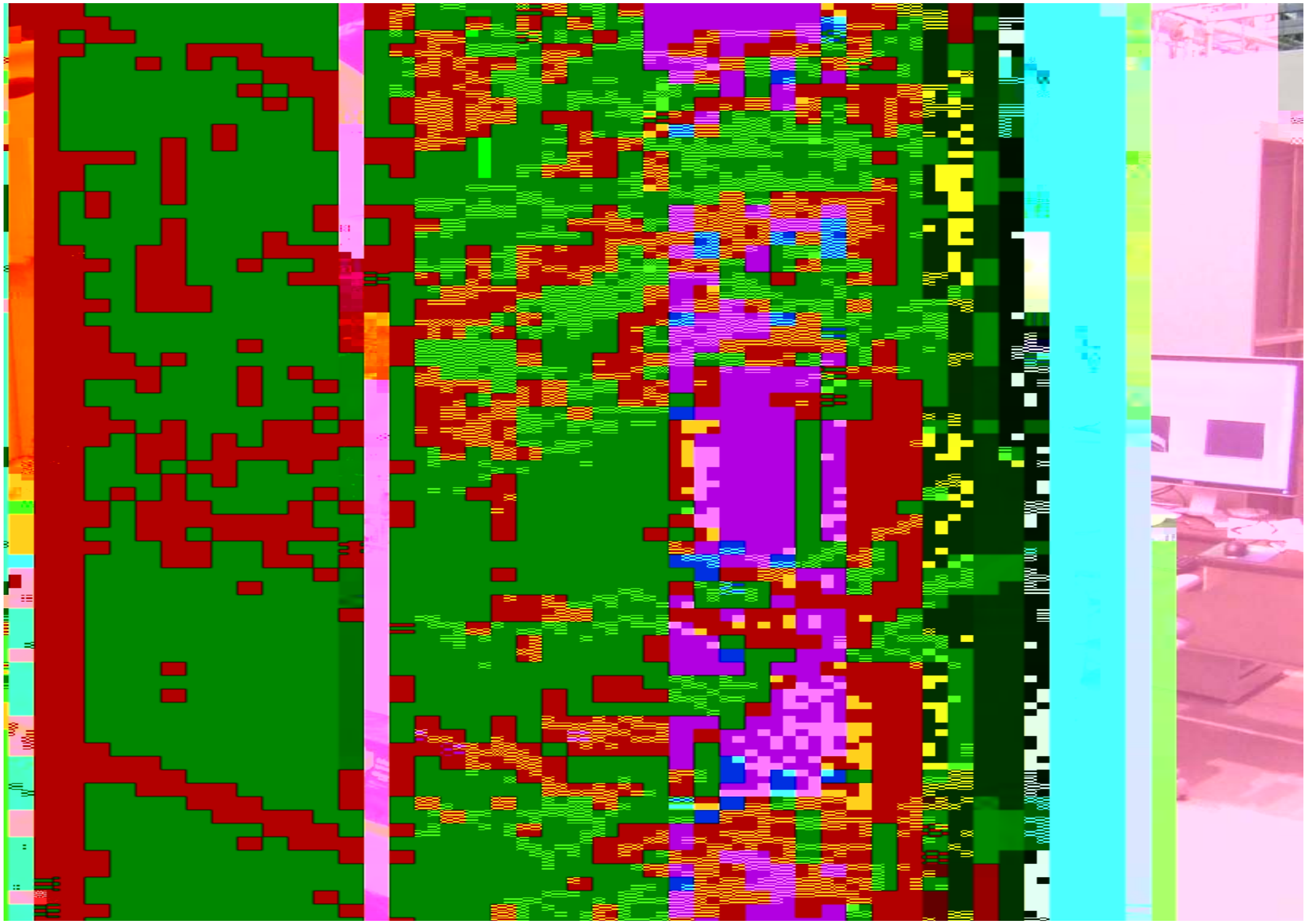


Â **Design and construction of 30 stage 5-cm contactor pilot plant**

Â **Temperature profile testing in the newly constructed contactor pilot plant**

Development of Remote 5-cm Centrifugal Contactor

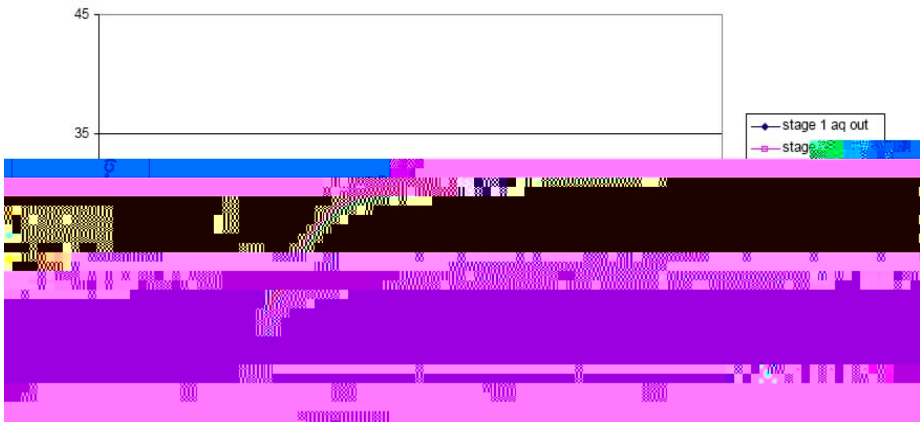
30 Stage 5-cm Centrifugal Contactor Pilot Plant



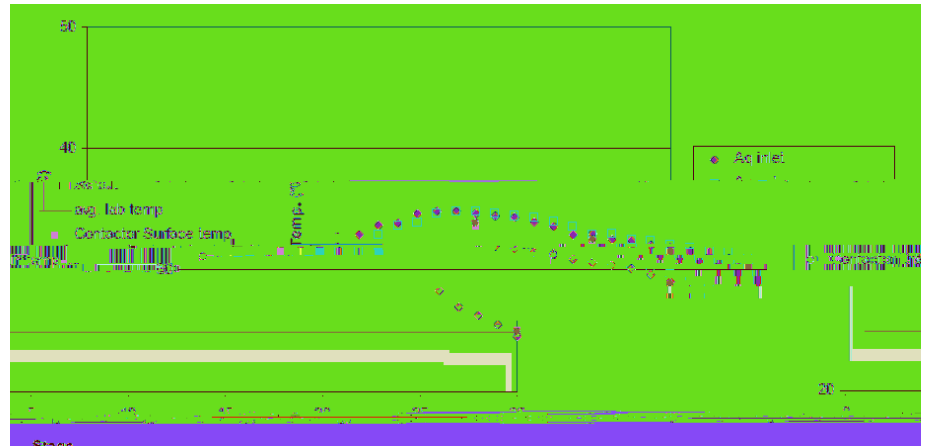
Test Objectives of Temperature Profile Testing in 30 Stage Pilot Plant

- **Aqueous separation flowsheets typically require some level of temperature control – often different for various sections**
- **Laboratory scale centrifugal contactor testing (2-cm) results in large temperature increase for the process solutions due to heat generated from the motors and low flowrates**
  - 2-cm centrifugal contactors with heat exchanger jackets were designed and utilized to alleviate this issue
- **Will jacketed heat exchangers be required for engineering and production scale centrifugal contactors?**
  - With larger flowrates it is expected that the temperature impact from motor heat will be reduced
  - Heating or cooling the process feed solutions may be enough to accomplish temperature control, preventing the need for a complex heat exchanger system for the centrifugal contactors
  - ANL has developed a computer model to predict process temperature based on system design. Limited experimental data is available - Data from testing will be used by ANL to validate/improve their model.

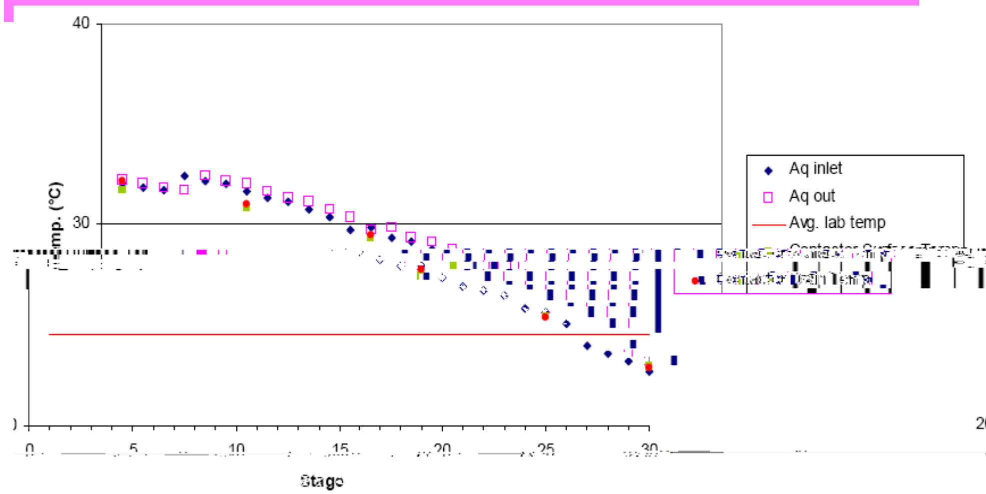
Temperature Profile Testing



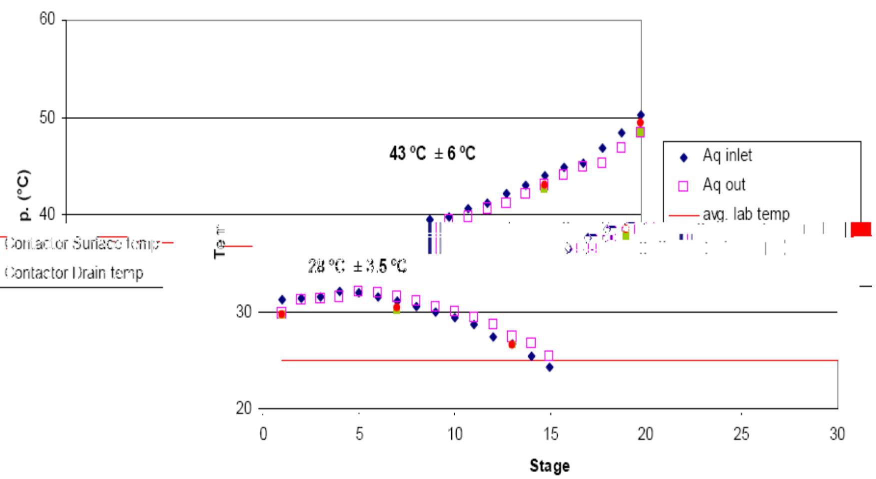
Aqueous Only – Approach to Steady State – Ambient Temp



Two Phase Flow – Temperature Profile – Ambient Temp



Aqueous Only – Temperature Profile – Ambient Temp



Two Phase Flow – Temperature Profile – Strip at 50C

Summary of Results of Temperature Profile Tests

- **Process solution temperature increased when feed solutions were at ambient temperature**
- **At feed temperatures of 50 ºC, heat losses were greater than the heat gain due to motor operation or heat of mixing which resulted in processes solution temperature decreasing below the feed temperature**
- **Control of the feed solution temperature has a significant impact on process solution temperature**
- **Process temperature control in flowsheets using CINC 5-cm centrifugal contactors could likely be accomplished for many flowsheets by controlling the temperature of the feed solutions**
- **Processes that require tighter temperature control may require jacketed contactor or insulation**

Testing Planned for FY 2009

- **A prototype remotely maintainable 12.5-cm centrifugal contactor will be constructed and tested**
- **TRUEX mass transfer testing and temperature control testing will be performed using the 30 stage centrifugal contactor pilot plant**
- **A location and layout that will allow testing of the pilot plant with depleted uranium and/or low levels of radiotracers will be evaluated**
- **A pulse column will be set up for testing**

Acknowledgements

Â **ORNL**

- J. Binder
- D. Ramey
- B. Spencer

Â **INL**

- D. Haefner
- J. Law
- T. Todd
- N. Soelberg

Â **SNL**

- T. Nenoff

Prepared by Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, Tennessee 37831-6285, managed by UT-Battelle, LLC, for the U.S. Department of Energy under contract DE-AC05-00OR22725.

Questions

R. T. Jubin

jubinrt@ornl.gov