Cold Testing Support for Fuel Cycle Facilities at ORNL

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Integrated Process Demonstration (IPD)

Nuclear Science and Technology Division

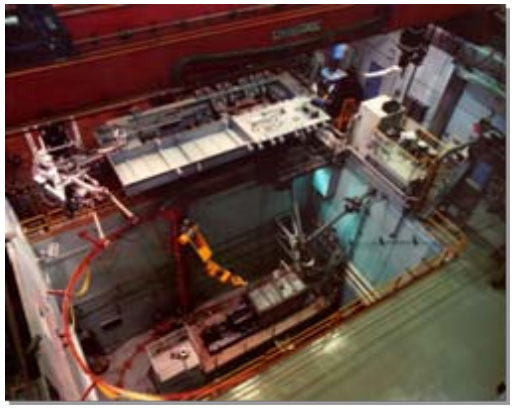
Purpose

- **Pilot-scale facility for “cold” testing and demonstration of chemical processes and equipment for use in fuel reprocessing under the Consolidated Fuel Reprocessing Program (CFRP)**
- **Responsible for installation, testing, and operation of advanced equipment and processes to support the reprocessing of spent nuclear fuels**

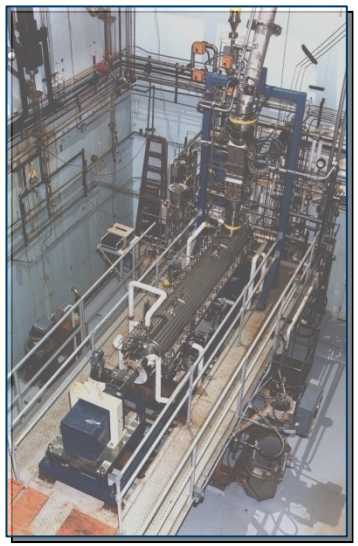
Description

- **The IPD simulated the first cycle of the PUREX flow sheet modified for advanced fuel reprocessing.**
- **The functions in the IPD were to:**
  - **test the functional operation of advanced components and systems**
  - **demonstrate integrated operation of prototypical systems**
  - **unmask undesirable interactive effects**
  - **provide a flexible test bed for experiments in areas such as safeguards, equipment reliability, and advanced process control including the automated operations of selected equipment and systems**

Photos of IPD



Head-end Systems

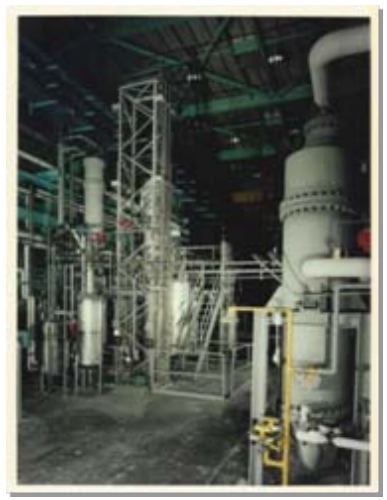


Dissolution

Accountability and
Product Evaporator

Pulse Column
Solvent Extraction

Centrifugal Contactor
Solvent Extraction



Waste Evaporator

Solvent Washing

What Went Well

- **Startup, checkout, and operating procedures**
- **Operator training program**
  - **Combination of classroom, field, and OJT**
- **Shift change-over**
  - **Shift overlap**
  - **Detailed shift log**
- **Test plan/Test Instruction documentation**
- **Interactions and cooperation between Operations and Research staff**
- **Dedicated craft support**
- **Control room separated from interruptions and distraction**

What did not go so well

- **Equipment**
  - **Leaky valves and fittings due to corrosion**
  - **Evaporator demister corrosion**
  - **IODOX system operated for minimal time**
  - **Silicone lubricant used on ball valves was incompatible with process chemistry**
- **Chemical hazards**
  - **Hyperazeotropic HNO_3**
  - **Uranium oxides and metals**
- **Instrumentation checkout**
  - **Repetitive use of checkout procedures on numerous similar instruments**
- **Control system checkout**
  - **Checkout took longer than planned**
- **Incidents and occurrences**
  - **Radiological events due to inexperience and past practices**

What did not go so well (cont.)

- **Operator training**
  - **Retraining schedule not well defined**
- **Laboratory analysis issues**
  - **Analytical results were sometimes inconsistent – frequent use of blanks recommended**
- **Shift turnovers and communications**
  - **Sometimes chaotic due to last minute field operations and sample collection**
- **Test change control**
  - **Approval system could be cumbersome**
- **Procedure development and modification**
  - **Approvals and reviews were time consuming**
- **Process and equipment drawings**
  - **Maintaining as-build drawings can be expensive**
  - **Use of red-lined drawings difficult to control**

Simulants

- **Spent Fuel**
  - **Depleted Uranium**
- **Solvents**
  - **Tributylphosphate in normal paraffin hydrocarbons (actual plant solvent)**
- **Issues**
  - **Solvent degradation products not prototypic**
  - **No fission products or Pu for separations testing**

Solvent Extraction Test Facility (SETF)

Nuclear Science and Technology Division/ Nonreactor Nuclear Facility Division

Purpose

- **Pilot-scale facility for performing remote hot cell operations for potential use in fuel reprocessing under the Consolidated Fuel Reprocessing Program (CFRP)**
- **Responsible for installation, testing, and operation of remotely operated equipment and processes to support the reprocessing of spent nuclear fuels**

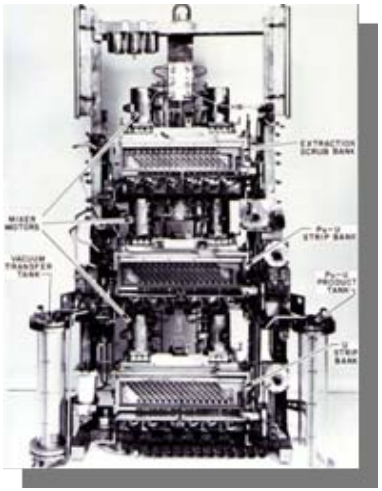
Equipment/Process Description

- **The SETF has successfully demonstrated the PUREX, TRUEX, Talspeak, and UREX flow sheets for advanced fuel reprocessing as well as other nuclear material processing.**
- **The SETF consisted of:**
  - **3 remotely operated and maintained equipment racks - right rack 5 (RR5), left rack 5 (LR5), and back rack 5 (BR5) - located in a heavily shielded cubicle.**
  - **associated process tankage located within tank pits contained in several hot cells**
  - **chemical make up area where “cold” solutions are made up and distributed to the equipment racks and process tanks**

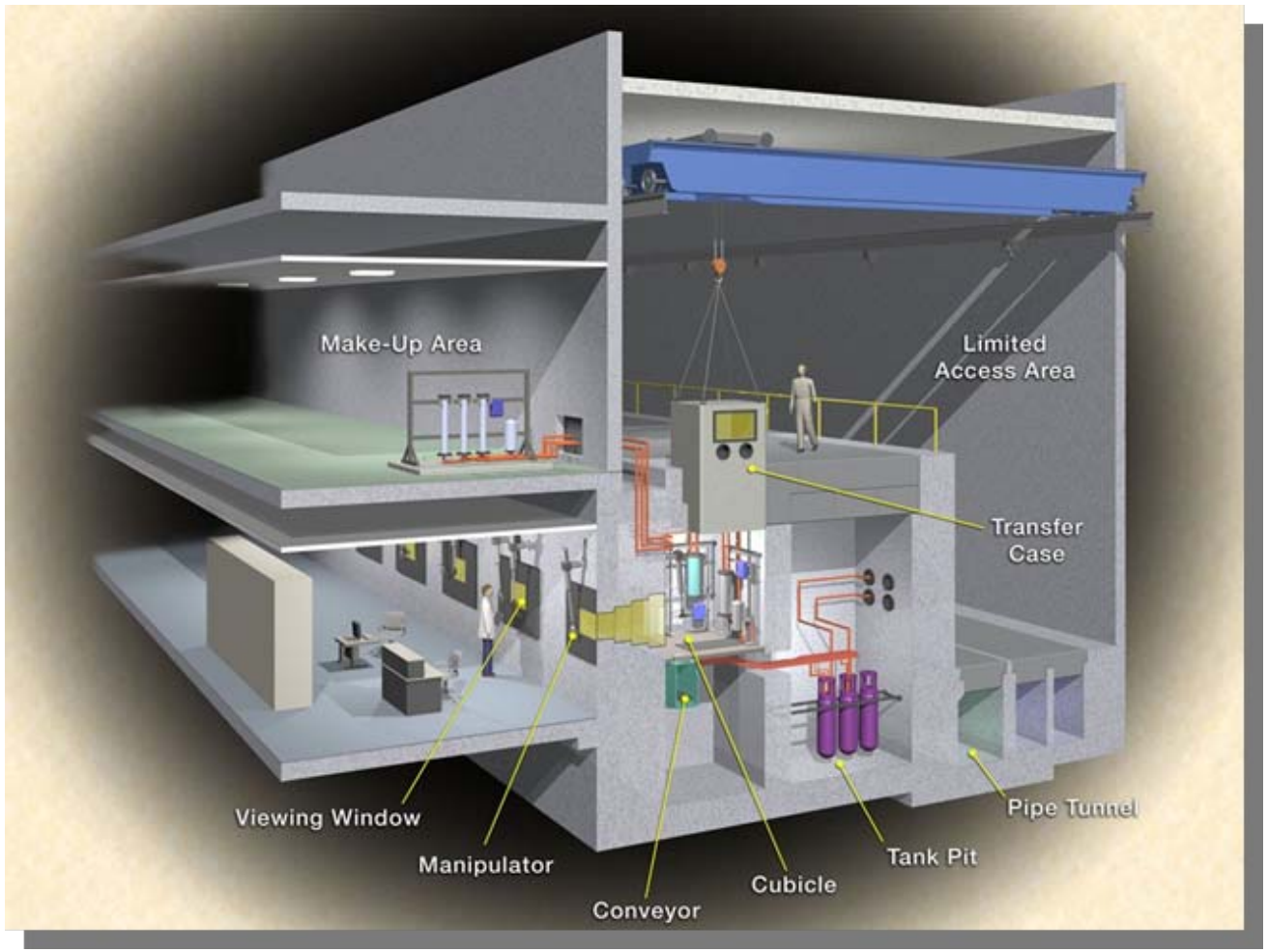
Equipment/Process Description (cont.)

- **RR5 – dissolution of spent reactor fuel, feed adjustment and accountability, feed tanks for BR5 operations**
- **BR5 – mixer settlers for product extraction, scrubbing, and stripping operations that can utilize different solvent extraction flowsheets to achieved specific results**
- **LR5 – anion exchange resin columns for final product purification, tank sampling equipment, and miscellaneous vacuum/pressure solution transfer systems**

Photos of SETF Equipment



Cubicle 5 SETF Equipment



Unique Differences Between the SETF and the IPD

- **IPD was a much larger scale pilot plant operation. SETF was limited due to available tank volume.**
- **SETF operated with actual spent reactor fuel. No simulants were used. IPD operated with depleted uranium as simulated spent fuel feed material.**
- **All aspects of SETF operation and maintenance were performed remotely. IPD was primarily a hands on operation with limited remote operations for specific demonstrations.**
- **IPD primarily used centrifugal contactors for solvent extraction processing. SETF used mixer/settlers.**
- **SETF was operated on a 24/7 operating schedule. IPD was operated intermittently on a 24/5 schedule to support planned testing.**

What Went Well

- **Preliminary scoping experiments and lab scale testing for equipment design**
- **Testing/shake down of equipment prior to installation**
- **Stepped approach from “cold” to “hot” operation of equipment**
- **Operator training program**
  - **Used OJT during testing/shake down of equipment as initial training tool**
  - **OJT for “cold to hot” operations, since hot cell operations technicians initially trained during testing/shake down of equipment**
- **Shift turn over**
  - **Shift instructions issued Monday through Friday at end of normal day shift to ensure operational continuity and priorities**
  - **Operations personnel already experienced in 24/7 operations**
  - **Detailed shift log with focus on shift status**
- **Runsheet/Procedure preparation**

What Went Well (cont.)

- **Operations and Research staff responsible to same manager (minimized issues with prioritizing operations)**
- **Dedicated craft support**
- **Initial budget more than adequate to cover operations staffing, provide spare parts inventory, and provide essential maintenance support**

What did not go so well

- **Equipment**
  - **Some equipment components failed to meet expectations once installed in a remotely maintained and operated environment**
  - **Some equipment components experienced a shortened life expectancy due to high radiation fields**
  - **Some un-anticipated difficulties in remote equipment operation due to equipment rack design and configuration**
  - **Some equipment rack tanks proved to be too small for the process demands**
  - **Glass feed tanks had to be replaced with quartz tanks due to radiation exposure turning the glass virtually opaque in a short time**
  - **Equipment repairs were typically supported on day shift due to budget constraints resulting in limited number of craft personnel available**
- **Chemical hazards**
  - **NO gas sparge**
- **Radiation Control Valve (RCV) check out**
  - **Checkout was difficult due to location of radiation control valve and weak source strength**

What did not go so well (cont.)

- **Operator training**
  - **Did not have a formalized training program until 1981**
  - **All training done through "word of mouth" and OJT by individual shifts which created differing standards as to how work should be accomplished.**
- **Laboratory analysis issues**
  - **The pilot program did not anticipate the work load impact on analytical services**
  - **Analytical staff were overwhelmed by number of samples requested**
- **Process and equipment drawings**
  - **Maintaining as-built drawings can be expensive**
  - **Use of red-lined drawings difficult to control**

Advice

- **Ensure efficient communication**
- **Ensure minor materials compatibility**
- **Match personnel to job requirements**
- **Ensure adequate personnel to cover shift operation**
- **Maintain good working relationship between operators, R&D staff, and craft support**
- **Always keep management informed**
- **Keep as-built drawings up to date**