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Consolidated Fuel Reprocessing Program Progress Report for Period July 1 to September 30, 1985

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CONSOLIDATED FUEL REPROCESSING PROGRAM PROGRESS REPORT FOR PERIOD JULY 1 TO SEPTEMBER 30, 1985

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NOTICE: This document contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

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Foreword

The U.S. Department of Energy (DOE) sponsors all U.S. research and development on fuel reprocessing in one major program—the Consolidated Fuel Reprocessing Program (CFRP)—under the management of the Oak Ridge National Laboratory and the Oak Ridge Operations Office. Other major program participants are GA Technologies, Inc., where reprocessing research and development on the HTGR fuel cycle are done, and the Hanford Engineering Development Laboratory (HEDL).

The coverage is generally overview in nature. Experimental details and data have been limited to (1) make the report more concise and (2) meet the requirements which would qualify the report for unrestricted distribution in the open literature.

1 Highlights

All research and development on civilian power reactor fuel reprocessing in the United States is managed under the Consolidated Fuel Reprocessing Program (CFRP) centered at Oak Ridge National Laboratory (ORNL). Technical progress is reported in overview fashion in this series of quarterly progress reports.

1.1 PROCESS AND ENGINEERING R&D

W. S. Groenier

The United Kingdom (U.K.) solid bowl centrifuge modified by the incorporation of a ZrO_2 bushing and sleeve has been tested successfully. Operation at solvent extraction feed polishing conditions has been demonstrated for the duration of a 30-d campaign.

Tests of a pulsatile fluidic pump in the Integrated Equipment Test (IET) facility have been completed, and experimental and predicted results agreed within 10%.

Problems with concentration and temperature profile matching and with mass balances in the computer code that describes a single-column selective absorption process for krypton removal from off-gases have been resolved.

At Battelle-Pacific Northwest Laboratory (PNL), ion implantation tests using multiple gas-trapping modules connected to a single manifold were successful. This concept for scale-up of the process is feasible. These tests complete the planned ion implantation program at PNL.

Modifications to the shaft and coupling region of the two-stage 5.5-cm-diam centrifugal contactors fabricated at Savannah River Laboratory (SRL) have eliminated dynamic balance problems, and the rotors are now stable throughout the speed range 0 to 4400 rpm.

Greater than 95% cascade efficiency was achieved during uranium mass-transfer tests in the four-stage experimental centrifugal contactor. The loss of one intermediate stage is accommodated by overflow ports and results in continued operation with a decrease in cascade efficiency to ~90%.

Earlier problems with plutonium material balances during dissolution of high-burnup Fast-Flux Test Facility (FFTF) fuel in hot-cell studies and in the Solvent Extraction Test Facility (SETF) have been resolved. The problems arose from difficulties in analyzing solutions where >75% of the alpha activity was from curium.

Fuel-pin fabrication is under way for the irradiation test of direct press spheroidized (DIPRES) fuel material in the FFTF. A series of scouting tests established calcining and pellet pressing parameters.

1.2 ENGINEERING SYSTEMS

M. J. Feldman

The remote disassembly system and shear system have successfully undergone operational qualifications demonstrated by the disassembly and shearing of a Clinch River Breeder Reactor (CRBR) dummy fuel assembly.

Remote handling tests using the Central Research Laboratories (CRL) M-2 servomanipulator were completed on several types and sizes of compression fittings for use in small fluid lines.

The transporter that will be used to position and provide mobility for the advanced servomanipulator (ASM) has been fabricated. Construction of the control room for the transporter and ASM has been completed.

Both the dissolver system and the centrifugal contactor extraction systems worked well during the week-long Integrated Process Demonstration (IPD) run using powdered U_3O_8 as the feed material.

1.3 INTEGRATED EQUIPMENT TEST FACILITY OPERATIONS

O. O. Yarbro

The second IPD experimental uranium processing campaign of FY 1985 was completed in September. This campaign featured the first fully integrated operation of the dissolver and the solvent extraction systems for a sustained period at matching process rates of 500 kg of uranium per day. The processing work demonstrated the capability to detect the diversion of material from process streams, further defined operational control procedures in the dissolver and solvent extraction systems, and established operational confidence with integrated equipment operation.

Revisions were made to the Distributed Data Acquisition and Control System (DDACS) in order to accommodate the Environmental Test Chamber (ETC) instrumentation and to support additional automation of the dissolution system.

The initial phase of a special remote connector test program was completed in the Remote Operation and Maintenance Demonstration (ROMD) area. During this test, the remote handling characteristics and performance of selected off-the-shelf tubing and pipe connectors were evaluated.

The travel of the secondary bridge crane in the ROMD area was modified to extend over the shear and disassembly systems for performing remote maintenance demonstrations. Switching trolley positions and raising the operating level of the telescoping tube used for the M-2 manipulator were also required to perform the remote demonstrations on these systems.

Construction of the ETC is in progress and is expected to be completed in February 1986.

1.4 STRATEGIC PLANNING AND ANALYSIS

J. G. Stradley

A study, which examines mixed-oxide (MOX) fuel cycle options for the liquid metal reactor (LMR), is being completed.

Eight critical experiments were performed by PNL for the criticality data development program sponsored jointly by the United States and the Power Reactor and Nuclear Fuel Development Corporation (PNC) of Japan. A total of 15 experiments have now been performed of the 77 defined by the program.

1.5 BRET PROJECT

S. A. Meacham

During this quarter, technical activities related to winding down the project and documentation for the project design file were completed.

1.6 HTGR FUEL REPROCESSING

W. S. Groenier

In the high-temperature gas-cooled reactor (HTGR) dry head-end development, a 75-h run was completed in the 20-cm-diam burner to furnish a realistic iodine and simulated semivolatile fission product–impregnated off-gas stream for the off-gas treatment system.

Fort St. Vrain shipping cans and baskets were completed and loaded with 648 irradiated fuel rods for shipment to the Federal Republic of Germany for AVR-VI tests.

2 Process and Engineering R&D

W. S. GROENIER

The Process and Engineering R&D group identifies improved processes and components, develops these concepts on a laboratory and/or bench engineering scale, and provides process parameters and equipment criteria. Objectives in FY 1985 are to (1) reprocess ultrahigh-burnup (~100,000-MWd/t) FFTF fuel samples in the SETF while evaluating solvent extraction flowsheet options and control schemes, (2) evaluate design options for the BRET-scale centrifugal solvent extraction contactors which have the potential for significantly improving contactor reliability and performance, (3) complete the evaluations of the U.K. centrifuge for dissolver solution and solvent extraction feed clarification and the pulsatile fluidic pumping units for various small reprocessing plant applications, (4) fabricate fuel pins at HEDL for an FFTF irradiation test using DIPRES mixed (U+Pu) oxide feed material prepared by ORNL in FY 1984, and (5) initiate evaluation and/or confirmatory testing of selected special chemical systems required for small plants, which currently lack data-base support because of small-scale or novel features.

2.1 ENGINEERING ANALYSIS, DESIGN, AND SUPPORT

W. S. Groenier

This activity includes task coordination of several activities in the Fuel Recycle Division (FRD) and work in other ORNL divisions, the student cooperative education program, and other ad hoc CFRP efforts. A consulting subcontract with Georgia Tech Research is also included which provides, among other activities, a review of electrochemical applications for solvent extraction.

2.1.1 Electrochemical Reduction Modeling

A. Schneider and J. Donniacuo (Georgia Tech)

Modifications of the SEPHIS computer code which allow modeling of a solvent extraction cycle with an interstage electrochemical reduction cell were continued, and efforts began to develop an experimental program for verification of the model using short-residence-time contactors.

Oscillations previously encountered in the computer code which prevented obtaining a steady-state solution were minimized by modifying the subroutine that describes the electrochemical cell. Additional analysis is necessary, however, to resolve a problem involving the cascade material balance. The SEPHIS-MOD5 code incorporated a subroutine describing the electrochemical cell and uses a different set of flow streams for the stages on either side of the cell. This arrangement is different from previous versions of the SEPHIS code and has brought about the material balance problem.

2.2 SPECIAL CHEMICAL SYSTEMS DEVELOPMENT

B. E. Lewis

2.2.1 Centrifuge Development

J. G. Morgan

Tests and evaluations of a solid-bowl centrifuge (U.K. design) are continuing, and improvements for the drag bushing to increase its life are being investigated. Assessments of solids inventory and solvent extraction feed polishing are included in the evaluations.

The reference breeder fuel reprocessing flowsheet specifies a polishing centrifuge located immediately before the first solvent extraction contactor. This centrifuge is intended to operate continuously throughout a campaign to remove any solids not removed by the primary centrifuge or any that form during feed adjustment.

Initial testing of a ZrO_2 bushing has been completed. The centrifuge was operated trouble-free for 575 h at 10,000 rpm with a ZrO_2 lower bushing rotating in a housing with a ZrO_2 insert. The feed stream to the centrifuge was composed of a mixture of Fe_2O_3 powder and water. Excessive vibration began after 575 h of operation; furthermore, it was noted that the bypass liquid flow that normally lubricates the bushing had almost completely stopped. To increase the flow of liquid around the bushing, the radial clearance between the bushing and insert was increased by honing the insert. This modification did increase bypass flow but did not eliminate the vibration. Other possible causes for the vibration, such as turbine bearing wear, quill warpage, and upper bushing wear, are being investigated.

A second metallic bushing and housing material was also tested in which the contacting surfaces were converted to chromium carbide by a chemical vapor deposition process. The base material was heat-treated type 440C stainless steel. A test of these materials was made with the centrifuge operating at 10,000 rpm and a water flow of 20 L/h. After 450

h of continuous operation, the centrifuge was stopped and restarted. Upon restart, excessive friction stopped the bowl rotation. Examination of the bushing and holder showed that the carbide surfaces had worn away, exposing the base metal. It was concluded that the very thin coating (8 to 10 μm) applied by this method was not adequate for this application.

2.2.2 Fluidics R&D

J. G. Morgan and W. D. Holland

Evaluation tests of pulsatile fluidic pumps for various applications are continuing. A pulsatile fluidic pump demonstration was successfully completed in the IET facility. The 4-ft-tall pump, made from 4-in.-diam pipe, was installed in a 3000-L tank containing uranyl nitrate solution with a specific gravity of 1.47. Operation was carried out remotely from the IET control room. The pump discharge line was 22 ft in length and lifted the liquid a vertical distance of 13.5 ft into a receiving tank. At a motivation pressure of 35 psig, the pump delivered 380 L/h under full host tank conditions. This dropped to 140 L/h when the tank level dropped to 2 ft and the pump chamber was only half full. Operation was not significantly different when the fluid temperature was increased from 40 to 90°C. The predictive mathematical model was used to analyze the data. Experimental and predicted results agree within 10%.

2.2.3 Special Chemical Systems

B. E. Lewis, W. D. Holland, R. M. Counce, and H. J. Marquess

This activity initiates the study of and subsequent necessary development for the following special chemical systems: (1) steam jets, (2) feed preparation system, (3) fluid pumping units, (4) high-temperature fluid transfer systems, (5) steam stripper, (6) evaporators, and (7) secondary dissolver.

Steam-jet pumps have been specified for several locations in the reference breeder reprocessing flow diagram, but small-scale applications (such as the feed to the primary centrifuge) may require such low flows that steam jets may be impracticable. A commercially available low-flow steam jet has been tested in the IET facility.

Typically, dilution levels in the range 1 to 5% were obtained with delivery rates <1 L/min. High-temperature transfers (~80°C) with flow rates <1 L/min gave dilution levels as high as 27%.

Review of the in-cell pumping requirements for a small-scale reprocessing plant is complete. Of the 104 in-cell pumps specified in the reference flowsheets, 62 are steam jets, 15 are air lifts, 5 are reverse-flow-diverter (RFD) fluidics, 7 are RFD fluidics in conjunction with water wheels, 8 are centrifugal, and 2 are recirculators. Several changes in pump choices were suggested based on modernization and implementation of various advanced pump designs. A report detailing the conclusions of this study is currently in preparation.

Experiments have been planned to evaluate the performance of dual overhead condensers for use in the dissolver off-gas (DOG). The double overhead condenser design was selected to better enable the recycle of condensate to the dissolver and passage of I_2 in the DOG. To successfully accomplish these tests, a method of sampling and analyzing the DOG stream must be developed. An experiment has been set up to test various means of sampling a simulated DOG stream comprised of known amounts of I_2, NO, NO_2, H_2O, and air. The initial tests will use gas samples for NO_x concentration measurements, magnesium perchlorate for water determination, and KI solutions for I_2 concentration measurements.

2.3 AIRBORNE WASTE MANAGEMENT

R. T. Jubin

2.3.1 Off-gas Treatment Systems

R. T. Jubin and D. K. Little

The development of improved computer models for various dissolver off-gas treatment systems, which was begun in FY 1984, is being completed. In particular, a model describing the single-column fluorocarbon absorption process for recovery of krypton and xenon from an off-gas stream is being improved. The original model was based on earlier separate-column models for absorption and fractionation, each of which was verified by experimental data. Successful combination of the separate models into a single program has been frustrated by a lack of knowledge concerning feed and product stream compositions at the interfaces between absorption, fractionation, and stripping in the single-column system. The single-column model requires iterative calculations to arrive at a unique set of conditions that enables the concentration profile in each column section to match up with the profile in the adjacent section. Problems with matching column temperature profiles were also addressed.

To date, the major problems concerning krypton material balances and temperature profiles have been solved. Current efforts are addressing a further problem, which involves the nitrogen balance. The program currently does not account for nitrogen in a material balance and allows no change in nitrogen concentration below the condenser.

2.3.2 Ion Implantation Development

E. D. McClanahan (Battelle-Pacific Northwest Laboratory)

Ion-implanted specimens have been prepared at PNL using radioactive krypton in copper-yttrium matrices for the purpose of determining the effects of radiation on both the implantation process and the sputtered product. Three 150-Ci laboratory-scale experiments were performed.

The testing and evaluation of three types of target power supply and current limiters capable of operating full-scale krypton trapping units were completed. One of the units

provides a reasonable compromise of flexibility to meet process demands at reasonable efficiency and with reasonable capital cost.

Simultaneous operation of single and multiple gas-trapping modules without auxiliary pumping was successfully demonstrated with 1000 and 1500 cm^2 substrate area units. These tests showed that scale-up by the addition of pumping units to a common manifold is possible and that benefits from mutual pumping by adjacent units during an electrical fault in another unit are real.

The radioactive specimens previously prepared will be monitored for stability while stored in Building 503. Building modifications have been completed, and the samples have been purged with argon in preparation for the move to the storage area.

2.4 SOLVENT EXTRACTION DEVELOPMENT

R. T. Jubin

2.4.1 Solvent Extraction Test Facility

L. J. King, D. E. Benker, and F. R. Chattin

A major solvent extraction campaign was performed in Building 7920 with ultrahigh-burnup (~100,000-MWd/t) FFTF fuel that was cooled ~1 year. The campaign, completed in May, evaluated reference and alternate flowsheets using in-line process control with a feedback loop. The recovered plutonium was converted to PuO_2 by oxalate precipitation for return to HEDL. A summary of results was reported in the previous progress report (ORNL/TM-9734).

Equipment cleanup from the solvent extraction campaign was completed. In addition, the solution containing all the americium and curium which had been recovered from the aqueous waste solutions in previous campaigns was processed to remove about 100 g of rare earth fission products. The processing steps included a Cleanex batch extraction to remove most of the impurities and two LiCl-based anion exchange runs to separate the rare earth elements from the actinides. The final product solution contained 14 g of ^{241}Am and 2 g of ^{244}Cm. The overall decontamination from europium was greater than a factor of 10^3.

2.4.2 Contactor Development

R. T. Jubin, R. M. Counce, and S. F. DeMuth

This activity continues the basic development of centrifugal solvent extraction contactors utilizing (1) a single-stage unit to explore additional improvements in performance by varying internal geometry and (2) a four-stage unit to evaluate a new design concept that allows operation to continue after failure of one motor drive. A concept for driving the four stages from a single motor is also being evaluated. Further work involves acceptance tests of the 5.5-cm-diam units fabricated at SRL for a small-scale facility.

Work to improve the dynamic balance of the two-stage SRL unit was completed. Following the modifications, it is now possible to operate the unit over the entire range of 0 to 4400 rpm without excessive vibration.

Fabrication was completed on the new experimental rotor, which has a removable bottom to test various tapers and a removable top to allow the evaluation of various length aqueous vanes.

Mass transfer studies using the 5.5-cm-diam experimental contactor have been initiated. In these tests, uranium is extracted from 3 *M* nitric acid using a 30% tributyl phosphate–normal paraffin hydrocarbon (TBP-NPH) solution. In initial experiments using a single-stage contactor, the couette height was varied from near zero to full height. At an organic-to-aqueous ratio of unity and a throughput of 0.5 L/min, Murphree extraction efficiencies of 77, 97, and 100% were obtained at couette heights of 0.64, 3.5, and 7.0 cm. Characterization studies of the single-stage unit are expected to continue in an effort to better understand the relationship between extraction and residence time in the mixing region.

The initial mass transfer testing of the four-stage experimental unit has indicated that the cascade efficiency is greater than 95%. When the cascade is operated with the third stage dead (not operating) and fixed with overflow ports, the cascade efficiency decreased to ~90%.

2.4.3 Solvent Extraction System Analysis

R. T. Jubin

Computer codes for solvent extraction system analysis are being improved by updating the UCOR subroutines within the SEPHIS and MATEX codes to include new equilibrium data.

Recent work with the U.K. low-TBP distribution data for nitric acid, uranium, and plutonium has shown a strong bias toward an unusually low plutonium distribution coefficient when using the modified UCOR subroutine. A modified equilibrium constant has been developed to accommodate the problem.

Additional low TBP data obtained from the British are being entered into the distribution coefficient data base and will be analyzed for consistency and to confirm the value of the modified equilibrium constant.

2.5 HOT-CELL STUDIES

J. T. Bell

This activity supplies FFTF fuel samples for use in the SETF and performs limited fuel dissolution and dissolver residue characterization studies.

2.5.1 Fuel Characteristics and Dissolution Behavior

D. O. Campbell, J. C. Mailen, and D. R. McTaggart

Analyses for chromium in dissolver solutions from high-burnup FFTF fuel indicate that some, but not all, of the fuel cladding is subject to corrosion by nitric acid. In one test the chromium dissolved by nitric acid was undetectable, whereas in another test 1576 μg was dissolved in ~5 h at 100°C. This represents ~0.57% of the chromium in the cladding in the dissolver. The cladding in the two dissolution tests was from different lots. Chromium is known to accelerate the corrosion of stainless steel by nitric acid; the apparent corrosion of the cladding should be further investigated to determine if this is important for increasing the corrosion of dissolvers constructed of stainless steel.

Comparison of the quantities of ruthenium found in dissolver solutions with those predicted by the ORIGEN code indicates that only 1 to 2% of the total ruthenium was dissolved. This gives a decontamination factor for ruthenium of 50 to 100 for the dissolution step. The weight of residue recovered from the dissolver and compositions of residues determined in earlier studies (determination of residue composition is not currently possible) indicate that more than half of the residue was not separated from the hulls. A qualitative gamma scan of a hull showed a large quantity of ruthenium; efforts are currently under way to obtain quantitative gamma scans of the residues and hulls. The data indicate that ruthenium is not easily separated from the hulls and may constitute a problem in hull handling subsequent to the dissolution step. The French have reported a problem of high background radiation due to ruthenium on hulls with an indication that the ruthenium can become mobile, probably as dust, and cause damage to filter systems.

The earlier problem with plutonium material balances has been resolved through replicate sample analyses; the material balances are now about 100 and 120% for the plutonium recovered in two dissolutions. The difficulty appears to be in the alpha pulse height analyses of solutions for which >75% of the counts are high-energy alphas from curium.

Gamma scans of the two intact fuel pins show significant migration of cesium to the pellet-pellet interfaces. Complete gamma scans at these interfaces show much larger relative concentrations of cesium than the average in the fuel column.

The remaining fuel pins from all FFTF fuels obtained by the program will be sheared this fiscal year. Sections from near the center of the high-burnup fuel (burnup of ~100,000 MWd/t) and near the end (burnup of ~80,000 MWd/t) will be reserved for use in hot-cell studies during FY 1986. The remainder of the fuel will be sheared in a consolidated batch and stored for use in SETF studies during FY 1986.

2.6 CONVERSION PROCESS DEVELOPMENT

W. S. Groenier

2.6.1 DIPRES Engineering Studies

M. D. Jackson (Hanford Engineering Development Laboratory)

This activity supports fabrication of test pins at HEDL for an irradiation confirmation test of DIPRES feed material in the FFTF.

Calcining and pelletizing tests were completed which established the DIPRES production feed calcining parameters to produce fuel pellets within the reference 90.4 ± 2% theoretical density target. A calcining temperature of 700°C and soak time of 4 h were selected. Fuel pellet fabrication tests were also completed to determine final pellet punch and die set dimensional requirements, and the necessary die set tooling was prepared.

Fuel-pin component inspections and release activities have been completed, providing all of the necessary fuel-pin components for the assembly of the DIPRES irradiation test pins. All of these components, which include cladding tubes, end caps, reflectors, plenum spacers, and springs, are standard FFTF inner zone fuel-pin components.

2.7 ANALYTICAL CHEMISTRY DEVELOPMENT

D. A. Costanzo

2.7.1 X-ray Fluorescence

J. M. Keller

The development of X-ray fluorescence (XRF) as an analytical technique applicable to reprocessing facilities is continuing.

All equipment for the Philips constant potential X-ray generator to be employed on the high-gamma XRF system has been received. Installation and testing of the generator should be completed by the end of October.

3 Engineering Systems

M. J. FELDMAN

The scope of the work performed in the area of Engineering Systems includes the design, procurement, and development of prototypic equipment for breeder reprocessing facilities. The IET facility will be used for testing the combined equipment systems and the remote operation capabilities and characteristics of these components and systems.

3.1 COMPONENT DEVELOPMENT

R. H. Chapman

Component development activities are directed toward performance demonstration of prototypic process equipment that can be remotely operated and maintained. Work includes designing, fabricating, and testing pilot-plant-scale components under realistic conditions. Current activities in the areas of dissolution and solvent extraction are reported below.

3.1.1 Dissolution

Dissolution system components are being developed for use in the head-end process of a remotely operated and maintained fuel reprocessing plant. During this reporting period, a scheduled dissolution run was performed successfully. Also, effort continued on preparing a series of reports that document dissolver development activities during the past few years.

IET Rotary Dissolver

J. F. Birdwell and F. E. Weber

The dissolver, dissolver off-gas, and solids recycle systems and the feed station were operated to dissolve U_3O_8 powder into a feed solution for a subsequent one-week process

demonstration run with the solvent extraction system. The equipment performed reliably during the dissolution run.

Prior to the IPD run, corrosion-resistant 17-4 PH stainless steel shafts were installed in two of the self-aligning drum support rollers to replace the 440-C stainless steel shafts installed originally. As noted in the previous report, the 17-4 PH material was used successfully for the other two support rollers, whereas less corrosion-resistant 440-C stainless steel shaft material proved unacceptable in the dissolver environment. One of the new shafts has small material defects that cause excessive wear on the Graphitar bearings, and new material is on order to replace the defective shaft.

The dissolver system control software was modified to permit operation in a mode that is more realistic for an integrated head-end process in a fuel reprocessing plant. The software modifications included operation of the feed station to simulate cyclic operation of the shear and adjustment of the acid feed to compensate for the hold periods when simulated fuel feed was not being fed to the dissolver. The system was operated successfully with the modified control software during the IPD run in September.

3.1.2 Solvent Extraction

Solvent extraction component development involves work on BRET-sized centrifugal contactors at SRL and additional tests and evaluation of components, primarily the pulse column and the two 8-stage centrifugal contactor units, installed in the IET solvent extraction system. This reporting period was devoted to resolving design deficiencies with the advanced centrifugal contactors obtained from SRL and to minor system modifications that improve operation of the IET solvent extraction system.

Advanced Centrifugal Contactors

M. E. Hodges (Savannah River Laboratory)

Because of design deficiencies that did not surface during testing of the two-stage prototype unit, balancing the rotors of the four-stage and the eight-stage BRET-sized (0.1-t/d) centrifugal contactors proved difficult and was not totally successful. As a result, the units could not be operated at design speed, and testing at SRL was limited to verification of the hydraulic design over only a portion of the operating range. Since resolution of the design problems will be time consuming, further development activities on these units at SRL was terminated, and they were shipped to ORNL for resolution of the problems.

Contactor Reliability Testing

P. A. Haas, L. D. Ladd, and J. F. Birdwell

Construction of a simple facility for long-term testing of the mechanical reliability of the contactors was completed. Installation and checkout of the utilities (power, control and

data acquisition instrumentation, etc.) are nearly complete. Shakedown of the facility, which can be operated unattended, is scheduled for next quarter. Reliability testing of the contactors will be delayed until the new motor drives are available.

Construction of a simple facility for long-term testing of the mechanical reliability of the contactors was completed. Installation and checkout of the utilities (power, control and data acquisition instrumentation, etc.) are nearly complete. Shakedown of the facility, which can be operated unattended, is scheduled for next quarter. Reliability testing of the contactors will be delayed until the new motor drives are available.

IET Solvent Extraction System

S. P. Singh and J. F. Birdwell

The system was operated considerably during this reporting period to investigate a number of topics of interest for improved performance and operating ease. Although operation of the two 8-stage banks of 12-cm centrifugal contactors was generally very successful, some minor disturbances with the motor speed control system were encountered and are being investigated. Performance of the entire extraction system was very good during the one-week IPD run in September.

3.2 SYSTEMS DEVELOPMENT

N. R. Grant

This work is directed toward the development of certain major mechanical components and systems required for fuel reprocessing. The goal of Systems Development is to design, fabricate, and operate pilot-scale, prototypic, remotely operable and maintainable equipment.

The tasks assigned to this area are the disassembly and cutting systems, receiving and storage systems, special remote systems, and remote control engineering. The receiving and storage task is not funded in FY 1985 and therefore will not be reported.

3.2.1 Disassembly and Cutting

J. H. Evans

The disassembly and fuel cutting task is responsible for the mechanical preparation of the fuel for downstream processing. The task is developing equipment that will remove the undesired components (such as inlet and outlet nozzles) from the fuel assembly and cut the remaining portion of the assembly into short pieces. The sheared product will expose the contained fuel for subsequent dissolution in the dissolver. The goal is to produce the necessary design, equipment, and data required for the successful operation of a prototypic system. A prototypic mechanical head-end consisting of a laser-disassembly system, a shear

system, and an overall control system has been installed in the Remote Operation and Maintenance Demonstration (ROMD) Facility. Development work on the system is under way.

IET/ROMD Disassembly, Shear, and Cutting Control Systems

E. C. Bradley, C. F. Metz III, B. S. Weil, and W. F. Johnson

During this reporting period, the integration of the control system with the mechanical systems was essentially completed. The head-end is now operational as demonstrated by the disassembly and shearing of a CRBR dummy fuel assembly. In addition to the above, considerable laser cutting development on the more economical skeleton dummy fuel was accomplished. Additional shearing was performed on scrap bundles.

Planning for the April 1986 integrated run was initiated. The shearing scenario was formalized, and prototypes of fixtures to package the depleted uranium pins during shearing were designed and fabricated. These fixtures will be tested during the next quarter with ceramic-filled rods.

Plans for the demonstration of the remote maintenance of the shear system and the remote changeover of the disassembly system from CRBR driver to CRBR blanket were prepared.

It is anticipated that a significant quantity of dummy fuel will be disassembled and sheared next quarter.

3.2.2 Special Remote Systems

S. L. Schrock (Westinghouse Advanced Energy Systems Division)

Special remotely operable components and systems that will be required by a nuclear fuel reprocessing facility or by other tasks in Component Development and Systems Development are being developed by this task. During this fiscal year these include remotely operable pipe and electrical connectors, prototypic equipment racks and support structure, and a cell transporter to give mobility to the servomanipulators. In addition, an area in Building 7603 is being prepared in which the equipment racks will be installed and used to test components of the maintenance system.

Remote Connectors and Jumpers

J. E. Richardson (Westinghouse Advanced Energy Systems Division)

Several improvements to pipe connectors and jumpers, including tools to handle and operate the connectors, are being developed. The primary improvements desired in the pipe connectors are the development of radiation-resistant seals, a decrease in the size and cost of the connectors, and improvements in the reliability and ease of remote handling.

During this period, handling tests using the CRL M-2 servomanipulators were completed on several types and sizes of compression fittings for tubing connections. These fittings were mounted on a test panel in different orientations and were used with various

shaped tubing jumpers. The tests generally included remotely breaking and remaking each connector a total of 25 times with periodic checks of leak tightness at 25 psig. These tests were part of an overall program that included handling tests on electrical connectors, completed previously.

Cell Transporter

D. Macdonald and J. E. Richardson (Westinghouse Advanced Energy Systems Division)

The transporter supports and provides mobility to the in-cell servomanipulators and consists of a bridge, a trolley mounted on the bridge, and a rigid mast crane mounted on the trolley. The manipulator package is then attached to the lower end of the crane's rigid mast assembly. Design and fabrication of a demonstration transporter unit, to be installed in a facility at ORNL, are being performed by the Harnischfeger Corporation.

During this period, fabrication of the unit was completed. Shipment is expected by mid-October. A reliability, availability, and maintainability (RAM) analysis of the transporter has been performed, and a report describing this analysis has been prepared.

Equipment Racks/South Test Area

R. W. Mouring

An area for testing the Advanced Integrated Maintenance System (AIMS) is being developed in Building 7603 adjacent to the ROMD test area. This facility will provide an area for development of equipment rack concepts, servomanipulator repair of such concepts, and space requirements needed for such maintenance.

In previous periods, the design of the equipment racks was initiated, and necessary building modifications were identified. During this period, a subcontract for the building modifications was placed, and fabrication of the racks was initiated in the ORNL shops. Definitive design of the racks, which is proceeding in parallel with the fabrication effort, is approximately 80% complete, and rack fabrication is 50% complete. Installation of the racks into the test area is scheduled for the end of the calendar year.

3.2.3 Remote Control Engineering

J. N. Herndon

Manipulator and Maintenance System Development

H. L. Martin, J. C. Rowe, D. P. Kuban, A. C. Morris, E. C. Bradley, and C. T. Kring

The purpose of this effort is to design, fabricate, and operate equipment and facilities for development of improved remote maintenance techniques for fuel reprocessing and

other hazardous environments. The basis for this effort is the use of bilateral force-reflecting servomanipulators, television viewing, and man-in-the-loop teleoperation for large-volume, nonrepetitive tasks in unstructured environments. The AIMS represents a prototype demonstration of the maintenance concepts that the Fuel Recycle Division will utilize for future demonstrations for any remote handling applications. Key features to be demonstrated in the AIMS include increased availability through modular remote maintainability of manipulator slave arms, improved operational flexibility through modern digital control techniques, servocontrol for overhead transporter systems, wireless signal transmission techniques for reduced cable handling, radiation-resistant television camera development, and improved operator efficiency through flexible man-machine interfaces.

With the AIMS control room completed, the advanced servomanipulator (ASM) equipment previously located in the Robotics Laboratory of the Instrumentation and Controls Division has been moved to the new facility. The items moved include the ASM arms, the ASM control system, the man-machine interface, the auxiliary control system, various color monitors, and miscellaneous cables and parts. For initial operation of the ASM arms, one slave arm will continue to be used as a master arm in a pseudo-master-slave mode until the new master arms arrive and become operational.

A laboratory experiment was performed to demonstrate the transmission of high-speed digital control signals between the ASM master and slave racks using a microwave link. With this communications system, the ASM controls continued to function normally, thus demonstrating the feasibility of the concept.

Fabrication of the low-friction/low-inertia master controller arms for the ASM has been completed. Assembly of the master controller arms is nearing completion, and installation of the arms in the new AIMS control room should be completed early next quarter.

The detail design of the AIMS interface package was completed, and fabrication and procurement were initiated at ORNL shops. The fabrication of the control system cabinets and consoles was completed, and they are being assembled and installed in the AIMS control room.

Studies and Evaluations

J. V. Draper (Clarke Ambrose Incorporated) and Y. Fujita
(Power Reactor and Nuclear Fuel Development Corporation, Japan)

The primary effort in this area is the Manipulator Comparative Testing Program, a cooperative effort with PNC of Japan to evaluate and document the performance of selected manipulator systems in simulated remote handling applications. The testing program in ROMD included a CRL M-2, a Japanese Meidensha BILARM 83A, and a Programmed and Remote Systems (PaR) Model 6000 as the manipulator systems and was completed last quarter. The data reduction and analysis have been completed during this quarter.

4 Integrated Equipment Test Facility Operations

O. O. YARBRO

The IET Facility Operations section is responsible for the overall operations of the IET facility, including facility preparation and equipment installation, systems and equipment checkout and start-up, performance of tests in the facility, and overall facility maintenance. The facility provides a capability for conducting chemical processing and remote equipment demonstrations. The objectives are to provide for the integrated testing of process equipment and flowsheets prototypical of a pilot-scale fuel reprocessing plant, and also for testing advanced remote handling equipment and techniques. The IET facility consists of two distinct areas: ROMD and IPD. The ROMD activity focuses on testing advanced remote handling equipment and techniques and demonstrating remote maintenance concepts on advanced prototypical reprocessing equipment. The IPD addresses the issues of process operations in the predominantly chemical processing portion of the fuel reprocessing plant.

4.1 IET OPERATIONS

D. R. Moser

This activity controls, coordinates, and executes the overall operational experimentation within the IET facility. The major tasks include planning and executing process operation and remote handling experiments, preparation of procedures, and data storage.

4.1.1 IPD Operations

J. E. Dunn, D. R. Moser, J. C. Suddath, and P. Welesko

The IPD operations focus on the testing and operation of processes and equipment prototypical of those intended for deployment in an advanced fuel reprocessing facility.

The second IPD uranium campaign was successfully completed as scheduled during September. The major objectives of the campaign were to determine the sensitivity of safeguards software designed to detect diversion of material from process tanks, control process flows to the centrifugal contactors and pulse column using uranium photometers, and control process flows to the rotary dissolver using a computer model to predict uranium and acid concentrations in the digesters.

In preparation for the September campaign, informal tests were conducted with the dissolver and solvent extraction systems using uranium. The first part of the dissolver test evaluated modifications on the drum rollers, and the remainder of the test checked out equipment modifications that required processing uranium in the system. The solvent extraction system tests were conducted primarily to check out process flow controls and operating problems corrected since the previous operation.

Tests and work completed on various process equipment not directly in support of the campaign during the quarter were as follows:

1. gadolinium monitor experiments in the chemical makeup area,
2. fluidic pump and low-flow steam-jet tests in specific process tanks, and
3. Iodox acceptance test plans and draft procedures for operating equipment.

4.1.2 ROMD Operations

T. W. Burgess

The ROMD operations focus on testing remote handling equipment and techniques and demonstrating remote maintenance concepts on advanced prototypical reprocessing equipment.

The initial phase of the remote connector test program was completed. The remote handling characteristics and performance of selected off-the-shelf tubing and pipe connectors were evaluated. Thirty connectors (15 jumpers) mounted in various configurations on a portable test stand were tested using the M-2 servomanipulator. All connectors were operated successfully, and approximately two-thirds withstood 25 cyclings without damage or loss of seal integrity.

Preparation for the M-2 force-nonforce test was initiated, but the experiment has been delayed pending delivery and setup of a six-axis force sensor for recording test task loading data. The utility of force feedback in the performance of remote handling tasks will be evaluated in this test program.

Dissolution system sampling using the ROMD automated sampling system was demonstrated in the September IPD campaign. The system was also operated throughout the quarter to investigate spurious control system errors and to check out control software modifications.

4.2 IET ENGINEERING

W. W. Evans

The IET Engineering is responsible for the management, planning, and implementation of activities associated with the installation and maintenance of process equipment and service systems in the IET facility and the CFRP site.

4.2.1 Facility Engineering Support

R. V. Eberle, W. W. Evans, and R. G. Grubb

Engineering efforts were primarily directed toward modifying equipment for small-scale experiments and improving equipment operation in preparation for the IPD campaign completed in September.

The travel of the secondary bridge crane in the ROMD area was modified to extend over the shear and disassembly systems for performing remote maintenance demonstrations. Switching trolley positions and raising the operating level of the telescoping tube used for the M-2 manipulator were also required to perform remote demonstrations on these systems. The demonstrations are expected to be initiated in the first quarter of FY 1986.

Equipment modifications were made before the September campaign to change the method of transferring material from the digester tanks through the feed and accountability systems. The material was transferred directly from the digester tanks with large jets to a surge tank prior to transferring from this tank to the centrifuge with small low-flow jets. The centrifuge was raised 18 in. to allow gravity flow to the accountability tank.

A number of piping changes were made to test safeguard procedures for material diversions during the September campaign. A gadolinium monitoring system was also installed in the IET chemical makeup area. The neutron source (2 Ci ^{241}AmBe) required in the monitoring system was shielded with paraffin inside a stainless steel box. The sensing detector electronics were connected to the IET control room for display.

4.2.2 Environmental Test Chamber

B. B. Spencer

An Environmental Test Chamber (ETC) is being constructed to study removal of chemical contaminants from cell atmospheres and to provide a place for routine exposure of process equipment to such atmospheres for testing and evaluation.

The expected completion date for construction of the ETC is early 1986. Major efforts to date have concentrated on demolishing the east-most section of the voloxidizer platform, relocating the power transformer used by the ETC, and sandblasting the existing structures to remove the old paint in preparation for repainting with special epoxy paint.

Two test plans were written describing the acceptance tests to be performed on the ETC when construction is completed.

A user's guide for the Low-Flow Ventilation System Simulation (LFVSS) program was written and reviewed. The program was adapted for use on personal computers, and a section describing the personal computer version was written.

4.3 INSTRUMENTATION AND CONTROLS SUPPORT TO IET

J. A. Hawk, M. S. Hileman, and R. G. Upton

4.3.1 Distributed Data Acquisition and Control System

J. A. Hawk, M. S. Hileman and R. G. Upton

A complete EPN redistribution was done on the DDACS system to accommodate the ETC instrumentation. The CAM and INTERLOCK data bases for the ETC will reside in process control module (PCM) 8. Several more contact input EPNs were allotted to PCM 11 to support additional automation of the dissolution system.

Work to demonstrate the digester automatic filling and sampling using the advanced technology liquid sampling (ATLS) vehicle is continuing. The interlock software (PCM 11) flow charting has been completed, and the code is written, compiled, and ready for testing. The protocol for DDACS-ATLS communications has been established, and the actual code is being written to send commands from DDACS to the ATLS vehicle.

Several software developments and modifications were performed in support of the September IPD uranium run.

4.3.2 Component Development Data Acquisition and Control System

M. S. Hileman and R. G. Upton

The software that was written to allow the IBM personal computer to retrieve and store selected archival data from the CODEDACS disk is now being routinely used by the FRD staff. Programs have been written by FRD personnel to convert the EPN data on the personal computer to a format read directly by FORTRAN programs.

Several modifications and enhancements to the DDACS-CODEDACS archival routines have been implemented to make them easier to use.

4.3.3 IET Process Equipment Instrumentation

J. A. Hawk and M. S. Hileman

Checkout of the electronics package for the gadolinium monitor was completed during this reporting period. Extensive troubleshooting was required to eliminate unstable and erratic drifting signals from the package. The alarm output from the gadolinium monitor was adjusted to shut down a simulated flow valve if the gadolinium concentration dropped below 10.5 g/L.

A third uranium photometer channel was added to measure the uranium concentration of the feed. Signals that indicate out-of-range uranium readings were added from the photometer control system to DDACS.

4.4 IET PLANNING

J. H. Shaffer

The IET planning activity coordinates requests from various R&D groups for experimental tests and demonstrations to be completed within the IET facility.

Planning activities have focused on specific tests that will be conducted by the IET operations staff during the balance of the calendar year. A test procedure for demonstrating the reliability of a gadolinium monitor was completed in the IPD chemical makeup system under conditions that simulated the in-line measurement of neutron poison concentrations in the acid feed to the dissolver. Test procedures were also prepared from test plans submitted for Component Development activities in solvent extraction. One test will investigate a method for detecting bearing degradation in centrifugal contactor drive motors. The second will establish control conditions for purge air to centrifugal contactor drive motors based on measurements of purge air flow velocities through the labyrinth seal around the drive spindle.

Plans for the start-up of the Iodox system have also stimulated programmatic interest in the basic operation of the dissolver off-gas system and in the capability of this system for transporting iodine from the dissolver to the Iodox system. Modifications in the dissolver off-gas system have been proposed for obtaining analytical samples from strategic stream locations. In addition, the installation of two condensers in series in an alternate piping arrangement of the dissolver off-gas system has been requested. The basic characteristics of both off-gas piping arrangements will be established, and their effects on iodine transport properties will be determined. The double overhead condenser installation was specified for use in the BRET for the recycle of condensate and passage of iodine in the dissolver off-gas.

The format for the second integrated IPD campaign with uranium (September 16–20, 1985) was established, and a summary description of proposed operations was prepared as a test plan. The novel feature of this campaign provided for fully integrated operations of the dissolver system, the solvent extraction system, and the included accountability and feed adjustment system. The test instruction prepared for this IPD campaign provided for 72 h of continuous operation of the rotary dissolver for processing about 1500 kg of uranium and solvent extraction at a matching rate of about 500 kg of uranium per day.

5 Strategic Planning and Analysis

J. G. STRADLEY

Efforts described in this section provide (1) information to guide the long-range activities of the CFRP, (2) a focal point for foreign exchange activities, and (3) support in specialized technical areas.

5.1 STRATEGIC STUDIES

5.1.1 Fuel Cycle

H. R. Yook

A collaborative study conducted with HEDL to examine fuel cycle options for the LMR mixed-oxide fuel cycle was completed. Three options were evaluated in FY 1985, including (1) expansion of the FMEF/SAF/BRET complex, (2) a new fuel cycle facility to be colocated with the LMR complex, and (3) delayed closure of the fuel cycle for five to ten years.

Some of the significant results that appear to have strategic implications follow.

1. A concept for a complete fuel cycle colocated with an LMR generating station of 1300-MWe capacity has been developed which could be built for about $300 million in present dollars. Operating costs were also estimated.
2. The existing Fuels and Materials Examination Facility (FMEF) at Richland could be modified to include an expanded BRET facility which, with the existing Secure Automated Fabrication (SAF) line, could provide the same capability at a capital cost of about $170 million.
3. Fuel cycle costs for these two options range from about 11 to 13 mills/kWh, some 20 to 25% of total power costs from the station.
4. Some potential for cost reduction exists. However, in all likelihood, costs for an LMR fuel cycle cannot be brought down as low as the present LWR fuel cycle at today's uranium prices and particularly when utilizing small fuel cycle facilities.

5. With the present policy of handling spent LWR fuel by disposal, the dilemma of fissile supplies for LMRs is not readily resolved. One potential avenue was explored, although not in depth, in this study—namely, providing capability for reprocessing sufficient LWR reactor fuel initially in the colocated fuel cycle to provide fissile needs for the station. Additional capital costs were not high (only about 10 to 20% addition to original costs), but the contribution to overall fuel cycle capital costs is higher since the facility would have to be built five to seven years earlier.
6. The delay of LMR fuel cycle closure could postpone investing in the reprocessing part of the fuel cycle, thereby lowering fuel cycle costs if plutonium were available from Europe at low costs ($5 to $10/g).
7. In analyzing total LMR fuel cycle costs, it is apparent that several considerations other than capital costs control them. These include capital charge rate, fissile costs, and operating costs.

5.2 FOREIGN EXCHANGE AGREEMENTS

The CFRP has active exchange agreements with the United Kingdom Atomic Energy Authority (UKAEA) and the PNC of Japan, and with the Federal Republic of Germany (F.R.G.) on HTGR spent fuel treatment (see Sect. 7).

5.2.1 U.S./U.K. Exchange Agreement

This agreement covers the areas of design parameters for a reprocessing plant demonstration; mechanical head-end, dissolution, and flowsheet technology; process control; instrumentation; and analytical chemistry.

The DOE and UKAEA are preparing a Specific Memorandum of Agreement for the loan of U.S. fiber-optic spectrophotometry equipment to the UKAEA. This equipment will be installed in the Dounreay Fast Breeder Reprocessing Plant, where operational data will be collected according to a jointly developed experimental plan.

Tests continued on the centrifugal clarifier that is on loan from the United Kingdom (Sect. 2.2.1).

5.2.2 U.S./PNC Exchange Agreement

In the remote systems technology area, preparation continued on the report describing the comparative testing of the Japanese BILARM 83A power manipulator, the M-2, and the PaR 6000 power manipulator. The BILARM 83A was packaged for return to PNC. Testing was initiated on the PNC high-definition television system (Sect. 3.2.3).

In the joint criticality data development area, eight critical experiments were performed at the PNC Critical Mass Laboratory (CML), for a total of 15 of the 77 defined by the program. The PNC CML has been given permission to use all the equipment

required for the remaining experiments. The joint program management plan, financial plan, and subcriticality measurement system (SMS) program plan were published.

Major equipment and software problems continued to prevent the SMS from being operational for experimental use. Several problems have been resolved but two remain. One, the SMS does not have the required dynamic range. Thus, the sampling rate is slower than desired. Second, the coherence values for two uncorrelated signals do not decrease as required with the number of data blocks. This limits the capability of the SMS when measuring low k-effective values.

5.3 MISCELLANEOUS STUDIES

5.3.1 RAM Analysis

M. J. Haire

Technical review of a report describing a RAM analysis of the ASM transporter system (i.e., bridge cranes and hoists) continued.

5.4 NUCLEAR ENGINEERING

M. J. Haire

The objective is to provide calculational support and technical guidance for the design of reprocessing equipment to be used where criticality and radiation damage are significant problems.

5.4.1 Nuclear Engineering Support for BRET

Criticality Analysis

J. A. Bucholz

Technical review was completed on the two-volume report describing the criticality safety analysis of the BRET main process cell (MPC) during normal conditions.

All of the process systems on the individual equipment racks were found to be safely subcritical under all normal conditions and most of the hypothetical abnormal conditions studied. The entire system is believed to have a neutron multiplication factor (k-effective) not greater than 0.6616. This calculation includes the interactive effects between the various components of the MPC.

Radiation Shielding Analysis

D. T. Ingersoll and S. N. Cramer

The PUTZ computer code utilizes the point kernel technique to perform scoping studies of radiation shielding design. The PUTZ computer code user's manual was prepared

and is undergoing technical review. The PUTZ code was demonstrated to run on an IBM personal computer.

5.4.2 Gadolinium Monitor

S. P. Cerne and M. J. Haire

A gadolinium monitor was installed in IET for a demonstration test. The test objectives were to verify (1) the long-term stability, (2) the capability of accomplishing in-line calibrations without disturbing the process, and (3) the low-level or gadolinium content alarm system. The long-term stability tests are being rerun because of some unexplained signal behavior. Acceptable data were obtained for the other two items. The IET calibration test showed that calibration data can be taken in about 1 min and therefore can be done without shutting down the process equipment. A safety signal test showed that the monitor takes less than 15 s to respond to the presence of a solution deficient in gadolinium.

5.5 SAFEGUARDS ASSESSMENTS

H. T. Kerr, M. H. Ehinger, T. L. Hebble, and J. W. Wachter

This work focuses on the development of advanced safeguards concepts for reprocessing plants and on the demonstration of practical capabilities afforded by these concepts. The primary near-term objective of this work is to demonstrate in the IET facility uranium loss detection capabilities achievable with advanced material control and accounting techniques. The integrated run of the IPD (Sect. 4.1.1) in April 1985 provided a reference data base and demonstrated the operability of the total data acquisition and analysis software system. The second integrated IPD run in September 1985 provided an opportunity to determine the uranium loss detection sensitivity of the various process monitoring tests. Planned removals of process solution were made under specified operating conditions. The safeguards tests detected all the planned removals but also indicated removals that did not occur—that is, false alarms. Further refinements in the test procedures will be required to minimize false alarms.

A parallel effort sponsored by International Atomic Energy Agency continues on the development of a process monitoring concept appropriate for an international safeguards application. A literature survey was completed, and significant process monitoring efforts were identified in a draft summary report.

5.6 SAFETY AND ENVIRONMENTAL MATTERS

M. B. Sears and T. D. Welch

This task provides guidance and coordinates assessments in support of CFRP activities to ensure that the facilities being designed will be radiologically and environmentally acceptable.

Work continued to wrap up the study to define the nuclide characteristics of BRET process streams. The base spent fuel case, 60 MWd/kg, was extended to 75 and 95 MWd/kg. The standard code has been adapted to provide an ORIGEN2 computer model for reprocessing FFTF spent fuel in BRET. The reprocessing stream case studies for reprocessing at 180 d and one year after discharge have been run for the reference burnup of 60 MWd/kg. The reprocessing case studies included decay of the products and wastes to ten years. A program has been written which condenses and reformats the ORIGEN2 output tables.

6 Breeder Reprocessing Engineering Test Project

S. A. MEACHAM

The BRET project had as its prime objectives the closing of the fuel cycle for the FFTF and demonstrating advances in reprocessing and remote maintenance technology under development in the CFRP. These objectives were to be accomplished by modifying an existing DOE facility, the FMEF, at Richland, Washington, to accommodate the reprocessing and maintenance equipment. BRET is a project undertaken in collaboration with HEDL.

6.1 PRELIMINARY DESIGN STUDIES

The BRET project has been deferred indefinitely and has been phased down. Technical activities were brought to logical stopping points, and both results and status were documented.

7 HTGR Fuel Treatment

W. S. GROENIER

Research and development activities in High-Temperature Gas-Cooled Reactor (HTGR) fuel treatment technology are being conducted at GA Technologies, Inc. (GA). Head-end process and laboratory-scale development efforts, as well as studies specific to HTGR fuel, are reported. The development of off-gas treatment processes has generic application to fuel reprocessing; progress in this work is also reported.

7.1 SPENT FUEL STUDIES AND ANALYSES

B. J. Baxter and M. E. Cohen (GA Technologies, Inc.)

7.1.1 Storage Studies

The preconceptual designs and descriptions of the three storage concepts under evaluation were used to complete the cost estimates and concept evaluations. Preliminary results show that concrete storage casks rate higher than open-field drywells or air-cooled vaults, but the final concept recommendation will await a detailed review of the evaluation results.

7.1.2 Transportation Studies

The maximum legal weight truck cask capacity was determined for each of the five waste forms examined for waste ages ranging from 100 d to 5 years out of reactor. Preconceptual designs were completed for the truck casks identified in the capacity study, and costs for fabricating those casks were estimated.

7.2 DRY HEAD-END DEVELOPMENT

B. J. Baxter and N. D. Holder (GA Technologies, Inc.)

A 75-h run was completed in the 20-cm-diam burner to furnish a realistic iodine and simulated semivolatile fission product–impregnated off-gas stream for the off-gas treatment system.

Fort St. Vrain shipping cans and baskets were completed and loaded with 648 irradiated fuel rods for shipment to the Federal Republic of Germany for AVR-VI tests.

The Fitzmill communitor was dust proofed and used for crushing 2 tons of commercial graphite. A hammermill supplied by Germany was dust proofed and installed in the pilot plant.

7.3 OFF-GAS SYSTEM

B. J. Baxter and J. Razvi (GA Technologies, Inc.)

The second integrated burner off-gas test was carried out successfully. During this test, burner effluent from the 20-cm-diam fluidized bed burner, spiked with simulated semivolatile and volatile fission products, was processed by the engineering-scale off-gas system for ~60 h. The major goal of this test was to determine the behavior and plateout profiles of the fission products in both the burner and off-gas piping. All components of the system showed stable operation during this test.

Additional bench-scale tests being carried out in light of mass balance discrepancies observed in earlier tests were completed. The new results showed iodine loadings in the AgZ sorbent generally lower by 10 to 30% than those obtained prior to making system improvements to obtain better mass balances. In terms of silver utilization, the 5% AgZ continued to show better loadings than the 10% AgZ.

7.4 WASTE HANDLING

B. J. Baxter, T. Roemer, and R. G. Wilbourn (GA Technologies, Inc.)

An expanded leach test was initiated in laboratory-prepared concrete/volume-reduced HTGR fuel stabilized forms. Preliminary results for concentration of fission products cesium, barium, and strontium in the leachates indicate good retention of these elements.

A module to calculate and display concrete stabilization data was added to the burner off-gas computer program BOGDESIGN.

A preliminary assessment on the applicability of nondestructive assay measurement techniques to stabilized HTGR fuel waste forms was completed.

Abbreviations

AIMS	Advanced Integrated Maintenance System
ASM	advanced servomanipulator
ATLS	advanced technology liquid sampling
BRET	Breeder Reprocessing Engineering Test
CFRP	Consolidated Fuel Reprocessing Program
CML	Critical Mass Laboratory
CODEDACS	Component Development Data Acquisition and Control System
CRBR	Clinch River Breeder Reactor
CRL	Central Research Laboratories
DDACS	Distributed Data Acquisition and Control System
DIPRES	direct press spheroidized
DOE	U.S. Department of Energy
DOG	dissolver off-gas
EPN	external point name
ETC	Environmental Test Chamber
F.R.G.	Federal Republic of Germany
FFTF	Fast-Flux Test Facility
HEDL	Hanford Engineering Development Laboratory
IET	Integrated Equipment Test
IPD	Integrated Process Demonstration
LMR	liquid metal reactor
MOX	mixed oxide
MPC	main process cell

ORNL	Oak Ridge National Laboratory
PCM	process control module
PNC	Power Reactor and Nuclear Fuel Development Corporation
PNL	Battelle-Pacific Northwest Laboratory
PaR	Programmed and Remote Systems
R&D	research and development
RAM	reliability, availability, and maintainability
RFD	reverse-flow diverter
ROMD	Remote Operation and Maintenance Demonstration
SETF	Solvent Extraction Test Facility
SMS	subcriticality measurement system
SRL	Savannah River Laboratory
TBP	tributyl phosphate
U.K.	United Kingdom
UKAEA	United Kingdom Atomic Energy Authority
XRF	X-ray fluorescence

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