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Consolidated Fuel Reprocessing Program Progress Report for Period October 1 to December 31, 1985

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CONSOLIDATED FUEL REPROCESSING PROGRAM PROGRESS REPORT FOR PERIOD OCTOBER 1 TO DECEMBER 31, 1985

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Foreword

The U.S. Department of Energy (DOE) sponsors all U.S. civilian research and development (R&D) on fuel reprocessing in one major program—the Consolidated Fuel Reprocessing Program (CFRP)—under the management of the Oak Ridge National Laboratory (ORNL) and the Oak Ridge Operations Office.

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 that would qualify the report for unrestricted distribution in the open literature.

1 Highlights

All research and development (R&D) 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

At Georgia Tech Research, an eight-stage centrifugal contactor (couette mixing design, 2-cm-diam rotors) has been reconditioned and installed in a laboratory facility for tests with an interstage electroreduction cell.

The latest version of the SEPHIS computer code for solvent extraction process modeling has been made operational on the International Business Machines personal computer (IBM PC). This time-dependent simulation is consequently now available to many more users because a large main-frame computer is no longer necessary.

Use of the United Kingdom (U.K.) feed clarification centrifuge as a final polisher for solvent extraction feed solution has been demonstrated using a centrifuge that was modified to allow long-term operation by incorporating a zirconia bushing and a zirconia-lined holder.

A successful 30-d demonstration has concluded the development activity for a solvent extraction feed delivery system that incorporates a pulsatile fluidic pump and waterwheel metering device.

A technical workshop on centrifugal solvent extraction contactor design and performance was held at ORNL and attended by about 30 visitors from industry and other U.S. Department of Energy (DOE) sites.

1.2 ENGINEERING SYSTEMS

M. J. Feldman

Cropping of simulated fast reactor fuel assemblies by laser cutting has been successfully demonstrated.

Interchange of structural components by remote means has been successfully demonstrated on the shear system. The interchange is necessary to reconfigure the shear to handle different types of fuel assemblies.

The transporter used to support and position the servomanipulators has been received and installed in the Maintenance System Test Area (MSTA).

Prototypical racks for process equipment were completed and installed in the MSTA. These racks will be used to develop and refine techniques for performing remote maintenance.

The two master arms for the advanced servomanipulator (ASM) have been fabricated and installed in the Advanced Integrated Maintenance System (AIMS) control room, which is adjacent to and used in conjunction with the MSTA.

1.3 INTEGRATED EQUIPMENT TEST FACILITY (IET) OPERATIONS

O. O. Yarbro

The acid concentration portion of the Iodox system was operated continuously for two separate 5-d periods. The system was checked out, and hyperazeotropic acid was produced during this operation.

The dissolver off-gas (DOG) system was modified, and initial iodine transport tests were completed. Preliminary examination of the experimental data indicates that the double overhead condensers in the modified dissolver off-gas line design allowed iodine to pass through and condensed water vapor to recycle back to the dissolver.

The automatic sampling of the digester tanks using the Remote Operation and Maintenance Demonstration (ROMD) automated liquid sampler was demonstrated. This milestone required the use of the integrated software from the process control module (PCM) level through the Distributed Data Acquisition and Control System (DDACS) host computer and back to the ROMD liquid-sampling-vehicle host computer.

1.4 STRATEGIC PLANNING AND ANALYSIS

J. G. Stradley

An agreement was signed between the DOE and the Commissariat a` l'Energie Atomique (CEA) of France to exchange information in the field of Remote Systems Technology.

Two critical experiments were performed by Pacific Northwest Laboratory (PNL) for the criticality data development program sponsored jointly by the United States and the Power Reactor and Nuclear Fuel Development Corporation of Japan (PNC-Japan). The Subcriticality Measurement System (SMS) was made operational, and verification experiments were initiated.

2 Process and Engineering R&D

W. S. GROENIER

The Process and Engineering R&D group identifies improved chemical processes and components and develops these concepts from a laboratory scale through full-size engineering prototypes. The primary objectives for FY 1986 are to (1) evaluate operation of the IET rotary dissolver, identify necessary improvements, and assess costs for implementation; (2) complete the evaluation of the improved bushings in the solid-bowl feed clarification centrifuge for extended life service; (3) explore additional centrifugal solvent extraction contactor parameter values for improved performance using an experimental modular rotor; (4) suitably modify the 5.5-cm-diam prototype centrifugal contactors to bring them up to operating specifications; (5) complete contactor reliability test stand and check out all systems; and (6) complete the tenth and final campaign in the Solvent Extraction Test Facility (SETF) using high-burnup Fast-Flux Test Facility (FFTF) fuel to explore flowsheet options and control schemes.

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, management of component development activities, the student cooperative education program, and a consulting subcontract with Georgia Tech Research, which will provide an assessment of electrochemical applications for solvent extraction. The maintenance and updating of solvent extraction computer codes (SEPHIS, MATEX, others) are also included as part of solvent extraction task management.

2.1.1 Electrochemical Reduction Modeling

A. Schneider (Georgia Tech)

The SEPHIS computer code, which models staged solvent extraction systems, has been modified to account for an interstage electroreduction cell. The modified code, called SEPHIS.5GT, is currently being adapted for operation on a PC.

2.1.2 Centrifuge Contactor Operation with Electroreduction

A. Schneider (Georgia Tech)

An eight-stage centrifugal contactor (couette mixing design, 2-cm-diam rotors) has been reconditioned and installed in a laboratory facility at Georgia Tech for tests with an interstage electroreduction cell. Initial hydraulic checkout tests of the contactor alone show appropriate flow capacities for the system ISOPAR *n*-dodecane (NDD) versus water. Tests with 30% tributyl phosphate (TBP) in ISOPAR versus dilute HNO_3 solution are under way.

The electroreduction cell has been obtained on a loan basis from Mound Laboratory. It is being fitted with a new membrane suitable for nitrate systems.

A low-pressure distillation system is being assembled for use in recovering uranium from dilute aqueous solutions to minimize waste volumes.

Current plans are to operate the contactor/electroreduction cell system with uranium for the purpose of verifying stage concentration values predicted by the modified computer code SEPHIS.5GT. A spectrophotometer will be used for U^{+4} and U^{+6} analyses.

2.1.3 Solvent Extraction Computer Code Development and Maintenance

R. T. Jubin

The Japanese computer code, PULCO, has been received and made operational in the ORNL computer system—with the exception of the graphics package. The major effort in the near term will be to gain an understanding of the internal functioning of this code, which applies to pulsed-column contactors in particular.

The SEPHIS code has been modified to include all the recent improvements to the UCOR subroutine and transferred to the IBM PC. This FORTRAN code is now completely operational on the IBM PC, and the changes do not affect either input or output data processing. Execution speed is about 1000 stage/time-step calculations per minute. Thus, for a user-specified time-step of 1 min, the IBM PC will simulate 100 min of operation each minute for a ten-stage contactor.

2.2 CONTINUOUS DISSOLUTION METHODS EVALUATION

R. H. Chapman

This activity continues the development and evaluation of continuous dissolution methods for nuclear fuel reprocessing. Objectives for FY 1986 are to complete modifications to the prototype dissolver initiated in FY 1985, evaluate operation from mechanical and solids inventory/throughput perspectives, identify additional necessary improvements (if any) and assess costs for implementation, perform scoping studies on an alternate (open-throat) drum, and provide assistance to IET operations as required.

2.2.1 IET Rotary Dissolver

J. F. Birdwell and L. D. Ladd

Minor operating problems encountered during the September integrated process campaign were investigated. The most significant involved air inleakage to the dissolver steam chest that was caused by misalignment of the faces of the large flange that joins the discharge chute to the steam chest. New gaskets and realignment are expected to correct the problem sufficiently for the next integrated campaign, but more definitive corrective measures will be required.

New type 17-4 PH stainless steel material was received for use in fabricating a replacement for one of the dissolver drum support roller shafts that has material defects. The new material was determined to have similar but much smaller defects. After consultation with Metals and Ceramics Division (M&C) personnel, a decision was made to use the material. Installation is planned for next spring. A heavy-duty gear reducer will be installed at the same time to improve the reliability of the drum drive system.

2.2.2 Documentation of Rotary Dissolver Development

F. E. Weber

Five reports documenting CFRP rotary dissolver development during the past five years were completed in draft form. Four will be published as internal documents, and one, a summary of the others, will be given external distribution.

2.3 SPECIAL CHEMICAL SYSTEMS DEVELOPMENT

B. E. Lewis

Special chemical systems include all R&D efforts on feed clarification centrifuges, fluidic pumps, steam jets, steam strippers, evaporators, and other chemical systems not included in other tasks. Objectives for FY 1986 are to complete the evaluation of the U.K. solid-bowl centrifuge, complete demonstration of pulsatile fluidic pumps in the IET

facility, perform a study of fluidics applications for off-gas control, specify where steam jets may be useful in the reference small-plant flowsheet, perform scoping tests of a small-scale steam stripper and evaporator, and evaluate various dissolver process options such as preheated liquid feed streams and double overhead condensers in the off-gas.

2.3.1 Centrifuge Development

J. G. Morgan

Tests and evaluations of a solid-bowl centrifuge (U.K. design) are continuing, and improvements to 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. It is intended that this centrifuge operate continuously throughout a campaign to remove any solids not removed by the primary centrifuge or that form during feed adjustment.

A successful demonstration was completed using the U.K. centrifuge as a polishing clarifier. The centrifuge bowl was fitted with a ZrO_2 bottom bushing rotating within a ZrO_2-lined holder. An average clarified solution flow rate of 32 L/h was maintained throughout the demonstration test with the centrifuge bowl rotating at ~11,000 rpm. The feed stream to the centrifuge was water with small amounts of Fe_2O_3 powder (0.2- to 15-μm diam) that were added periodically to the feed stream. Except for one short scheduled shutdown, the centrifuge operated continuously for 720 h (30 d). The operation was stable and trouble free.

2.3.2 Fluidics R&D

J. G. Morgan and W. D. Holland

The development of an alternate aqueous feed delivery system for use with the 5.5-cm-diam centrifugal contactors has been completed. The system consists of a combination of a fluidic pump and waterwheel metering device and can be used to supply feed to all contactors in a 0.1-metric ton/d capacity fuel reprocessing plant. The final shakedown test was successfully completed using water as the test fluid, and the system is now ready to be incorporated into the contactor reliability test stand in the IET. The shakedown test operated continuously for 30 d at an average flow rate of 70 L/h. The fluidic pump had a cycle time of 70 s (10 s for pumping, 60 s for refill), and the waterwheel was operated at 15 rpm.

Planning is under way to provide a reliable method for supplying feed to the IET feed clarification centrifuge. Using a pulsatile fluidic pump mounted in a thimble beneath the feed tank, operators will pump the solution vertically 18 ft to a small head-tank from which the solution will flow (averaging ~4 L/min) by gravity to the IET centrifuge.

2.3.3 Other Special Chemical Systems

B. E. Lewis, S. P. Singh, W. D. Holland, R. M. Counce, and M. A. Conger

The DOG double overhead condenser tests were completed. In these tests two condensers were installed in series in the DOG line from the rotary dissolver in the IET facility. The ability of the dual condensers to pass iodine and recycle H_2O and HNO_3 was studied. Five stations for gas sampling were designed and installed in the DOG line to monitor the performance of the condensers. Each sample station included a vacuum pump, flow meter, and the necessary tubing and valves to accommodate sampling for I_2, H_2O, and NO_x.

A successful analytical technique for the determination of iodine in a gas stream containing I_2, H_2O, and NO_x was developed. In this technique, iodine is removed from the gas stream by bubbling the stream through ~200 mL of 0.1-*M* NaOH solution in a standard wash bottle at a constant flow for a measured length of time. The analysis relies on the destruction of NO_x using urea (NH_2CONH_2), acidification, fixation with KI, and then titration for iodine with sodium thiosulfate ($Na_2S_2O_3$) and a starch indicator. The practical lower limit of detection for this technique is 0.001 mg/mL. The technique is not sensitive to organic iodides. Water determinations were made by measuring the weight gain of a drying agent through which the gas flowed at a known flow rate for a measured length of time.

Analysis of the NO_x content of the DOG stream was done by titrating the nitric acid formed from the conversion of all the NO_x in a gas-sample bomb to HNO_3 using peroxide. Any nitric acid vapor present in the gas sample prior to oxidation with peroxide would increase the reported amount of NO_x. A limited number of gas samples taken during the initial system tests served to establish baseline HNO_3 vapor levels because very little NO_x was present in the DOG in the absence of UO_2 dissolution. The NO_x detection limit for this technique is ~0.1% (volume).

A preliminary analysis of data from the condenser tests indicates that iodine was successfully passed through the condensers while water was recycled to the dissolver. Compilation and evaluation of the data are continuing.

Planning has begun on the installation and testing of a small-scale steam stripper for the recovery of NDD from a diluent wash stream in the back cycle system. A small (4- to 6-in. diam) packed column will be demonstrated under a variety of operating conditions. Design of the column has been initiated.

2.4 AIRBORNE WASTE MANAGEMENT

R. T. Jubin

This activity includes all residual off-gas treatment efforts in the CFRP. Objectives for FY 1986 are to complete descriptive computer models for the selective absorption and Iodox processes, support IET tests of the Iodox process, and document ion implantation development and monitoring of storage specimens.

2.4.1 Off-Gas Treatment System

R. T. Jubin and W. D. Holland

Work on the Iodox process computer model has been refocused on a code that is specific to the IET Iodox column. The more general system model will be developed later based on this specific code. Convergence problems have been corrected, and the code is now being evaluated using information from IET Iodox material balance flowsheets. Excellent agreement has been obtained between the hand calculations made during the design phase of Iodox and the new computer code results.

The Iodox code currently addresses the energy and HNO_3 and H_2O mass balances in the column but does not predict individual iodine decontamination factors (DFs) for each stage. An effort is under way to correlate DF data from the early Iodox work and provide some estimate of column performance.

A draft test plan for preliminary testing of the Iodox system under IET design conditions has been written. Tests include operation at the original design gas flow rate (which includes voloxidizer off-gas), at a reduced gas velocity (corresponding to a DOG without the voloxidizer), and with and without the anticipated NO_x concentrations.

2.4.2 Ion Implantation Development

E. D. McClanahan (PNL)

At PNL, the three multicurie Cu-Y-^{85}Kr ion implantation capsules were placed in a temperature-controlled storage system for observation of krypton release. Initial heat up to 150°C was completed. The first ^{85}Kr release measurements will be made after storage for three months at 150°C. Following these measurements, one capsule will be maintained at 150°C, while the temperatures of the remaining capsules will be increased incrementally to their final storage temperatures of 250 and 350°C.

Accelerated thermal release tests on the "cold" mock-up Cu-Y-Kr capsule used for the simulated multicurie run are continuing. No significant krypton release was observed after four weeks at 300°C. The temperature will be increased in ~50°C increments, and the release characteristics will be monitored over a four-week period. The maximum temperature for these tests will be 450°C.

2.5 SOLVENT EXTRACTION PROCESS DEVELOPMENT

R. T. Jubin

2.5.1 Solvent Extraction Test Facility

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

A tenth major solvent extraction campaign in the Building 7920 mixer-settlers will be performed using high-burnup FFTF fuel that is on hand. The recovered plutonium will be

converted by oxalate precipitation into PuO_2, which is a product suitable for return to Hanford Engineering Development Laboratory (HEDL). Objectives for the FY-1986 campaign are to further explore reference and alternate solvent extraction flowsheets using in-line process control with a feedback loop.

2.5.2 Contactor Development and Analysis

R. T. Jubin, R. M. Counce, S. F. DeMuth, and P. A. Haas

This activity will continue the development and testing of advanced centrifugal solvent extraction contactors. Objectives for FY 1986 are to explore additional improvements in performance by varying the internal geometry in a single-stage unit, evaluate improvements in reliability using a four-stage unit, assist the equipment development group in evaluation tests of prototype units for small reprocessing facilities, and learn more about contactors by performing specific tests and evaluations in the laboratory and by using descriptive computer models.

A centrifugal contactor technical workshop was held October 17–18, 1985. This meeting attracted about 30 visitors from outside ORNL who had interests in using centrifugal contactors in various operations. Communications with other sites regarding potential applications continues to be generated as a result of this workshop.

Previous communications with Westinghouse Idaho Nuclear Company (WINCO) have resulted in a purchase order contract to provide two contactor units. These will be of a design similar to the single-stage ORNL contactor and the four-stage unit with overflow ports. The WINCO unit will be fabricated entirely from stainless steel and will not have provisions for a multistage drive. Each stage will have a bearing assembly and drive motor subassembly.

Testing of the 5.5-cm-diam contactors fabricated by Savannah River Laboratory (SRL) continues. The primary objective of the tests is to provide data for use in the future selection of prototype drive units and for rotor design.

Requisitions have been prepared for the purchase of motors to be used in tests planned to aid in the selection of prototype 5.5-cm-diam contactor drive units. The intent is to perform reliability tests aimed at distinguishing the relative service lifetime and relative performance of ac single- and three-phase motors and dc motors.

The fabrication of the improved flow control and sampling systems for contactor mass transfer studies is complete. The new flow control system should maintain a constant flow within $\pm 2\%$. The new sample system should reduce the sample flow rate to $<5\%$ of the interstage flow at any point in the cascade. After system calibration, the four-stage ORNL 5.5-cm-diam contactor unit will be used to estimate the accuracy of the new systems by measuring the material balance around the cascade during operation.

Hydraulic testing of the newly balanced, SRL-fabricated, two-stage contactor has begun. Capacity data indicate maximum flow rates in excess of 4 L/min at 3500 rpm.

2.5.3 Equilibrium Data Correlation

D. O. Campbell

The work of upgrading computer codes for solvent extraction process analysis by improving the subroutines that contain equilibrium data and correlations will continue. Objectives for FY 1986 are to add new equilibrium data from the literature, develop and test new data-correlating algorithms, and identify regions requiring the measurement of additional values.

2.6 SOLVENT EXTRACTION PROCESS EQUIPMENT DEVELOPMENT

R. H. Chapman

This activity continues development and evaluation of prototype solvent extraction contactors. Objectives for FY 1986 are to procure mechanical drives for SRL-fabricated centrifugal contactors; design, fabricate, and test new prototype rotors; complete modifications to SRL contactors now in progress; complete installation of the contactor reliability test stand; perform a conceptual design study of contactor housings; complete modifications and installation of a spare IET contactor to investigate a surge overflow concept; evaluate the need for and install, if needed, additional DDACS data channels; and provide assistance to IET operations, as required.

2.6.1 Prototype Contactors

L. D. Ladd and P. A. Haas

Performance testing of the Breeder Reprocessing Engineering Test (BRET) sized (0.1 metric ton/d) centrifugal contactors over the full range of design conditions is occurring at ORNL. The motor/rotor assemblies have been evaluated, and the deficiencies have been observed which relate to fabrication misalignment and motor bearing quality. Rotors from the two-stage and the four-stage units have been reworked sufficiently to permit operation at the design speed. Although the supplied motors are unacceptable for long-term applications, they will be used until replacement drives can be procured. The new drives will be smaller versions of the high-quality milling machine spindles now in use on the 12-cm-diam IET centrifugal contactors. A new rotor design effort has been initiated that will carefully consider and incorporate fabrication procedures that will result in a well-aligned and balanced rotor.

2.6.2 Contactor Reliability Testing

P. A. Haas and L. D. Ladd

A test facility has been constructed for long-term evaluation of the mechanical reliability of the 5.5-cm-diam centrifugal contactors provided by SRL. The data acquisition

system was delivered and is now undergoing checkout. Shakedown of the facility is under way, using the eight-stage bank of contactors as received from SRL. Reliability testing of the contactors will be delayed until better drives are available.

2.6.3 IET Solvent Extraction System

S. P. Singh and J. F. Birdwell

Operation of the 12-cm-diam IET centrifugal has resulted in corrosion of one of the stage bearing assemblies. Examination of the spindle revealed that the bearing was corroded as a result of a small quantity of process fluid having entered the motor cavity during an operating upset condition. Consequently, a surveillance program has been initiated to monitor the vibration of each drive unit with time. Other modifications have been initiated to improve the reliability of the purge-air system that provides protection against fluids entering the spindle cavity.

2.7 HOT-CELL STUDIES

J. T. Bell

A limited hot-cell studies effort will continue that supports the SETF. Objectives for FY 1986 are to supply FFTF fuel samples for solvent extraction flowsheet testing in Building 7920, perform fuel dissolution and residue analysis tests necessary to resolve problems identified in FY 1985, and assist in the analysis of results obtained in the solvent extraction campaign.

The FFTF fuel to be used in the two SETF experiments has been identified, and shearing and packaging instructions have been given to the High Radiation Level Examination Laboratory (HRLEL) personnel. The fuel will be sheared during the first part of January. Sections from near the center of the high-burnup fuel (burnup of ~100,000 MWd/metric ton) and near the end (burnup of ~80,000 MWd/metric ton) will be reserved for use in hot-cell studies. The initial studies will examine removal of the large quantities of ruthenium remaining on the cladding after fuel dissolution with nitric acid. Physical methods (brushing) and leaching with HNO_3 and HNO_3-HF solutions will be tested. The topical reports covering the dissolution studies using low-burnup (~2,000 MWd/metric ton) and high-burnup (~100,000 MWd/metric ton) have been prepared.

2.8 CONVERSION PROCESS DEVELOPMENT

W. S. Groenier

The fabrication of test pins at HEDL for an irradiation confirmation test of direct press spheroidized (DIPRES) feed material in the FFTF is being completed.

2.8.1 DIPRES Engineering Studies

L. Rice and D. E. Rasmussen (HEDL)

This activity supports fabrication of test pins at HEDL for an irradiation confirmation test of DIPRES feed material in the FFTF. After conducting trial runs for the purpose of selecting production parameters for pellet pressing and calcining, the production operations have begun. Earlier delays in obtaining DOE approval for this activity, coupled with the length of time for scouting tests, may have caused the useful shelf life of the dried DIPRES spheres to be exceeded. Consequently, the spheres had to be fractured in a ball mill before pressing to achieve desired pellet characteristics. In spite of this unforeseen step, five of the six operations necessary for mixed powder fuels could be bypassed.

Current plans are to complete preparation of the fuel pins in January 1986 and insert them into cycle 9 of the FFTF scheduled for August–September 1986.

2.9 ANALYTICAL CHEMISTRY DEVELOPMENT

D. A. Costanzo

2.9.1 X-ray Fluorescence

J. M. Keller

This activity continues the development of X-ray fluorescence (XRF) as an analytical technique applicable to fuel reprocessing facilities. Objectives for FY 1986 are to evaluate a prototype system installed late in FY 1985, develop software for control and analysis, and initiate efforts to improve the optics of the XRF system if safeguards criteria indicate such a need.

Installation of the Phillips constant potential X-ray generator for the high-gamma XRF system has been completed. Operation of the generator has been successfully tested with a silver target X-ray tube. Current work involves the fabrication of an apparatus to support and permit alignment of the X-ray tube with respect to the spectrometer. In addition, an enclosure for the X-ray tube and entrance slit of the spectrometer is being fabricated for radiation containment.

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 mechanical 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 DISASSEMBLY AND CUTTING

J. H. Evans

The disassembly and fuel-cutting task, which is responsible for the mechanical preparation of the fuel for the downstream processing, is developing equipment that will remove the undesired components (such as inlet and outlet nozzles) from a 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 prototype system. A prototype mechanical head-end system consisting of a laser-disassembly system, a shear system, and an overall control system has been installed in the ROMD area of Building 7603.

3.1.1 IET/ROMD Disassembly, Shear, and Control Systems

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

A test sequence having the goal of establishing the laser-cutting parameters for crop cutting of fast reactor fuel was initiated. A successful cut was achieved using oxygen as the assist gas. Testing will continue investigating nozzle design, cutting speed, laser power, assist-gas composition pressure, and laser focal point.

The ROMD remote maintenance system was used to change the components required to convert the disassembly system to an alternate fuel configuration. All tasks were completed remotely, indicating a successful design.

Prototype fuel bundles for the April integrated run were sheared in the remote shear. Two designs were tested, one of which met the requirements. Additional bundles of the latter will be tested to verify adequacy.

Two equipment failures were experienced during the quarter. A leak developed in the rod seal of the in-cell shear actuator, and an electrical failure within the laser cavity required removal of the laser from service. Repairs are under way, and both units should be returned to service shortly.

3.2 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 are being developed. During this fiscal year these include remotely operable pipe and electrical connectors, prototype equipment racks and support structure, and a cell transporter to give mobility to the servomanipulators. In addition, the MSTA, Building 7603 at ORNL, has been prepared for testing components of the maintenance system.

3.2.1 Remote Connectors and Jumpers

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

Several improvements to pipe connectors and jumpers, including tools to handle and operate the connectors, are being developed under this subtask. 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.

In previous periods, handling tests were performed in ROMD on a variety of commercially available tubing and electrical connectors and fittings using the M-2 servomanipulators. During this period, one additional handling test was completed on a 2-in. pipe jumper with a gear-powered union. This jumper will be installed on the equipment racks in the MSTA. A test report for the handling tests is in preparation.

3.2.2 Cell Transporter

D. Macdonald

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 ASM package is then attached to the lower end of the crane's rigid mast assembly.

During this period, preassembly of the transporter was completed by the vendor (Harnischfeger), and the unit was shipped to ORNL. Installation of the transporter in the MSTA was completed during November, and hookup of the control system was completed and acceptance testing started at the end of December.

3.2.3 Equipment Racks/Maintenance System Test Area

R. W. Mouring

In previous periods, the design and fabrication of the equipment racks were initiated, the necessary building modifications for the MSTA were identified, and a subcontract for the modifications was placed. During this period, the building modifications and the fabrication of the racks were completed. The racks were delivered to the MSTA and installed on the support structure. Tie-in of the piping system to the mock-up penetration plugs is in progress.

3.3 REMOTE CONTROL ENGINEERING

J. N. Herndon

3.3.1 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 the design, fabrication, and operation of 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 FRD will utilize for a future demonstrations for any remote-handling applications. Key features to be demonstrated in AIMS include: (1) increased availability through modular remote maintainability of manipulator slave arms, (2) improved operational flexibility through modern digital control techniques, (3) servocontrol for overhead transporter systems, (4) wireless signal transmission techniques for reduced cable handling, (5) radiation-resistant television camera development, and (6) improved operator efficiency through flexible man/machine interfaces.

The AIMS control room, which was completed during the previous quarter, is being actively utilized. The two low-friction/low-inertia master controller arms were installed, and minor problems encountered with mechanical cables binding and internal parts rubbing were corrected. Software development and checkout for the two-arm master/slave operation are under way. Control software development is being actively pursued for the man/machine interface rack, the auxiliary control system rack, the pendant, and the local area network.

Fabrication of the AIMS interface package hardware was completed this quarter by ORNL shops; however, assembly will not be initiated until early next quarter because of the unavailability of externally procured gears. Fabrication of the planar camera positioner hardware is 30% complete, and all parts should be available to start assembly by the end of January.

A radiation-hardened television camera system was installed in the High Flux Isotope Reactor (HFIR) spent fuel storage pool environmental test chamber, and irradiation testing was initiated October 29, 1985. Testing is planned on the camera control unit until failure occurs. Exposure of over 10^7 rads was obtained by the end of this quarter.

3.3.2 Studies and Evaluations

J. V. Draper (Clarke Ambrose, Incorporated) and Y. Fujita (PNC-Japan)

A draft report on the manipulator comparative testing program was prepared. This report documents the results of a cooperative effort with PNC-Japan to evaluate the performance of Central Research Laboratories (CRL) M-2 manipulator, a Meidensha BILARM 83A, and a Geophysics Corporation of America (GCA)/Programmed and Remote Systems (PaR) Model 6000 manipulator system in simulated remote handling applications.

A draft report on the high-definition television comparison testing was also completed during this quarter. This report was presented at the DOE/PNC-Japan specialists meeting.

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 startup, 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 prototypic 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 Integrated Process Demonstration (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 prototypic of those intended for deployment in an advanced fuel reprocessing facility. No major processing campaigns were scheduled during the quarter. Work centered on testing individual components and systems.

The acid concentration portion of the Iodox system was operated continuously for two separate 5-d periods. The system was checked out, and hyperazeotropic acid was produced during this period. Resolution of minor equipment problems is in progress.

Iodine transport tests with the modified DOG system were completed. During the tests, the dissolver system was operated using dilute nitric acid (3.5-*M* HNO_3) without the dissolution of uranium oxide and operation of the digesters. Preliminary examination of the experimental data indicates that the double overhead condensers in the DOG lines allowed iodine to pass through and the water vapor to recycle back to the dissolver. Future iodine transport tests are planned with the actual dissolution of uranium oxide and digester operation.

The demonstration of totally automated sampling of the digester tanks using the ROMD automated liquid sampler was completed.

A second gadolinium monitor stability test is about 65% complete. The signal drifting problems have been eliminated.

One Standard Electrical Tool Company (SETCO) centrifugal contactor motor failed in the solvent extraction system. The motor was disassembled and its parts were decontaminated and prepared for shipment back to the factory for rebuilding.

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 reprocessing equipment.

The first remote maintenance demonstration of the Remote Disassembly System (RDS) was completed on schedule in October. This RDS subsystem demonstration evaluated the remote removal and installation of the system's Clinch River Breeder Reactor (CRBR) core- and radial blanket-type fuel adaptors. Remote operations were performed using the M-2 servomanipulator and the ROMD overhead gantry bridge hoists. The RDS fuel adaptors were successfully removed and installed without difficulty by intended procedures.

Preparations were completed for the ROMD operation's next scheduled test program, the M-2 servomanipulator force-nonforce reflection test. Evaluation of the utility of servomanipulator force feedback in performing remote-handling tasks is the primary objective of this experiment, which involves rigorously controlled test conditions and extensive data collection. A computer-based data acquisition system and associated instrumentation were installed in the area for recording test variables such as manipulator arm velocity, acceleration, and joint servomotor current drawn; test task loading; and task completion time. Test preparation also required the development of test tasks, test conditions and procedures, and training; operations will commence in early January and continue for an estimated nine weeks.

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 at the CFRP site.

4.2.1 Facility Engineering Support

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

The major portion of the engineering effort was directed toward modification of the DOG system, investigating the dissolver inleakage, and preparing the Iodox and acid concentration systems for operation.

The DOG system was modified to perform iodine transport tests using duel overhead condensers. The modifications involved installing two 6-ft heat exchangers, rerouting the dissolver 2-in. off-gas line through the condensers, modifying the off-gas outlet line location from the dissolver, and providing five gas-sample stations throughout the system.

A number of short-term studies were directed toward inleakage into the dissolver system. The inleakage was reduced during the series of tests by tightening flanges and seals.

Several minor equipment problems were found during the checkout and operation of the Iodox and acid concentration systems. A list of preoperational tests for various equipment items was prepared and proved useful in uncovering some equipment problems prior to the operation.

4.2.2 Environmental Test Chamber

B. B. Spencer

Construction of the Environmental Test Chamber (ETC) is about 45% complete. The overall contract includes both the ETC and the MSTA and is on schedule. Because the MSTA portion of the contract was completed in early December, construction efforts on the ETC are anticipated to become more intense during the remainder of the contract period.

Most of the masonry and concrete work has been completed. The interior walls were sandblasted to remove the old paint and were recoated with the special epoxy paint. Installation of the stainless steel ceiling was initiated. Piping and electrical work is under way and will continue till the end of the contract.

The three gas analyzers ordered for use with the ETC have been delivered. All three (the O_2, H_2O, and NO/NO_2) analyzers are undergoing checkout in the Instrumentation and Controls Division (I&C) shop.

A test plan was written covering the demonstration of pressure and temperature control in a low-flow ventilation system. The user's guide for the Low-Flow Ventilation System Simulation (LFVSS) computer program was completed.

4.3 I&C SUPPORT TO IET

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

4.3.1 DDACS

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

The software to automatically fill, cool, sample, and jet the digester tanks 07F03 and 07F04 was completed and tested this quarter. This milestone demonstrated the use of integrated software from the PCM level up through the DDACS host computer and down to the ROMD automated liquid sampling vehicle host computer. The revised INTERFACE software, which provides a high-level communications interface between DDACS and the operator, was also successfully demonstrated.

The I&C support was provided for two 5-d runs of the acid concentration portion of the Iodox system. The DDACS control system performed well during both runs. Hardware problems were of a minor nature and were corrected with no significant difficulty.

Work was begun this quarter on writing software for automating the accountability and feed adjustment systems for the April campaign. Work has also begun on creating the data bases for the ETC.

4.3.2 Component Development Data Acquisition and Control System (CODEDACS)

M. S. Hileman and R. G. Upton

Software modifications were made to the archival software to allow the archiving of up to 33 blocks of 23 external point names (EPNs).

Two CODEDACS hardware problems were experienced this reporting period. The spindle/brake assembly in the RA-80 disk drive was replaced, and the ac servo card on disk drive DL2 was also found to be faulty and was replaced. The problem in which the CODEDACS central processing unit (CPU) would occasionally hang was solved by replacing the LPA-11 hardware with a new revision.

4.3.3 IET Process Equipment Instrumentation

J. A. Hawk and M. S. Hileman

A failure of the variable frequency drive for the 8-2 contactor bank occurred during the December run. The main silicon-controlled rectifier (SCR) for phase B shorted before the run started. A new circuit board was purchased and installed. This SCR also failed shortly into the run. The area field service representative was called in to correct the problem, and the circuit boards causing the problem were replaced. The contactor motor drive functioned properly during the rest of the run.

An extended gadolinium monitor test was begun this quarter. The monitor electronics are now housed in an oil-tight National Electrical Manufacturers Association (NEMA)-12

cabinet, which protects the instrumentation from atmospheric contamination and electromagnetically transmitted noise interference.

Hardware to provide speed signals back to DDACS for Iodox pumps 28J12, 29J04, and 29J08 was received and mounted in a junction box near each pump's variable speed controller. Software was written to implement pump speed control schemes.

A hardware interlock to shut down the magnesium-nitrate crystallizer furnace when a preselected temperature set point is exceeded was installed. The hardware interlock is comprised of a Barber Coleman temperature limit controller that drives a magnetic power contactor.

The precision density meter (EPN: D29E06A) used to control the concentration of the 95% nitric acid produced in the acid concentration system was installed and wired to DDACS. This instrument furnishes DDACS with an analog density signal and an analog temperature signal corresponding to the temperature of the measuring cell (roughly the same temperature as the fluid being measured).

4.4 IET PLANNING

J. H. Shaffer

The IET planning activity develops requests for tests and demonstrations from the R&D groups of the CFRP for coordination with IET facility operations. Planning activities were primarily directed toward the development of operating procedures that supported the startup and demonstration of the Iodox system. The procedures were written to check out the equipment and provide operator training. Following the dilute acid operation, magnesium nitrate solution was introduced into the system, and hyperazeotropic nitric acid was produced by extractive distillation.

Test procedures were prepared for the operation of the dissolver system with dilute nitric acid (3.5-*M* HNO_3) but without uranium feed. Test objectives included measurements of off-gas moisture saturation levels and components concentrations. A specific study of iodine transport in the dissolver system was made in support of subsequent operations of the Iodox process equipment and was part of a performance evaluation of the double overhead condensers that had been installed in the DOG line.

5 Strategic Planning and Analysis

J. G. STRADLEY

5.1 STRATEGIC STUDIES

H. R. Yook

Final documentation of the oxide fuel cycle facility concept studied last fiscal year was completed. The results showed that an oxide fuel cycle facility to be colocated with a liquid metal reactor (LMR) generating station would require a capital investment of approximately $325 million (FY 1985 dollars).

5.2 FOREIGN EXCHANGE AGREEMENTS

The CFRP has active agreements with the United Kingdom Atomic Energy Authority (UKAEA), PNC-Japan, the CEA of France, and the Federal Republic of Germany (F.R.G.) on high-temperature gas-cooled reactor (HTGR) spent fuel treatment.

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 Specific Memorandum of Agreement for the loan of the U.S. fiber-optic spectrophotometry equipment to the UKAEA was signed, and the equipment was assembled. The equipment is expected to be shipped in January 1986. The equipment will be installed in the Dounreay Fast Breeder Reactor Reprocessing Plant, where operational data will be collected according to a jointly developed experimental plan.

An agenda is being developed for a joint control and instrumentation symposium to be held in the United Kingdom in 1986 involving technical specialists from each country.

Tests continued on the centrifugal clarifier, which is on loan from the United Kingdom (Sect. 2.1.2). The U.S. technical specialist in the flowsheet area (in conjunction with another trip) visited the United Kingdom to review reports being prepared to document information in this area. These reports have been developed jointly.

5.2.2. U.S./PNC-Japan Exchange Agreement

In the Remote Systems Technology area of the exchange, the report describing the comparative testing of the Japanese BILARM 83A power manipulator, the M-2, and the PaR 6000 power manipulator was completed and sent to Japan for review and comment. The BILARM 83A was returned to Japan. The testing program on the PNC-Japan high-definition TV system was completed (Sect. 3.3.2).

The Sixth Technical Specialist Remote Systems Technology meeting was held in Japan in December 1985.

The PNC-Japan assignee in the area of Remote Systems Technology returned to Japan, and a replacement arrived.

In the Joint Criticality Data Development area, two critical experiments were performed at the PNL Critical Mass Laboratory (CML) for a total of 17 of the 77 required by the complete program. The program plan was issued.

The problems reported last quarter concerning the SMS were resolved. It was established that the system was capable of performing all the required experiments. The verification experiments have been initiated.

5.2.3 U.S./CEA Exchange Agreement

The agreement between the United States and France to exchange information in the field of Remote Systems Technology was signed. A seminar was held that was attended by U.S. and CEA specialists.

5.3 NUCLEAR ENGINEERING

M. J. Haire

The objective of this task 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. The criticality and shielding studies done for the BRET project were documented in FY 1985. The only FY 1986 money funded under this task is associated with the gadolinium monitor. The monitor was installed in the IET in FY 1985 and tested to (1) verify the long-term stability, (2) establish the capability to accomplish in-line calibrations without disturbing the process, and (3) verify the low-level or gadolinium content alarm system. Satisfactory results were obtained for the calibration and the low-level alarm tests; however, an unexplained signal behavior was observed in the long-term stability tests. Some modifications were made to the electronics, and it appears from the results

of recent tests that the problems have been eliminated. The results for all the tests are being documented.

5.4 SAFEGUARDS ASSESSMENTS

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

This task is focused on the development of advanced safeguards concepts for reprocessing plants and on the practical capabilities afforded by these concepts. Several process-monitoring tests have been defined previously, and appropriate analysis software developed for use with data generated by the uranium systems in the IET (Sect. 4.1.12). Data obtained from a series of prescribed removals during the September 1985 IET run enabled the determination of solution loss detection sensitivity for the various tests. For most of the plant areas, the sensitivity achievable with the process monitoring tests appears to be adequate for many of the proposed U.S. Nuclear Regulatory Commission (NRC) regulatory goals. One problem in the September IET run was associated with the false alarm rate (i.e., many were noted); modifications have been made to various software in an attempt to reduce the number. A so-called "black-hat" exercise is planned for the April 1986 integrated run in IET to demonstrate the process-monitoring system capabilities, verify the reduction in false alarm rate and so forth, and establish where further developments are required.

A parallel effort continues on the development of a process-monitoring concept appropriate for international applications. A draft report describing the proposed major elements of this concept was approved by the International Atomic Energy Agency (IAEA) staff. The report also contains a summary of applicable process monitoring information available in the literature.

5.5 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.

A report documenting the application of the ORIGEN2 model for obtaining nuclide characteristics of process streams associated with the reprocessing of FFTF spent fuel is in preparation. The objective of the report is document data used in the BRET Environmental Assessment and to provide information useful in future projects for preliminary flowsheet design, environmental and safety analysis, reduction-shielding calculations, and heat transfer studies.

Abbreviations

AIMS	Advanced Integrated Maintenance System
ASM	advanced servomanipulator
BRET	Breeder Reprocessing Engineering Test
CEA	Commissariat a` l'Energie Atomique
CFRP	Consolidated Fuel Reprocessing Program
CML	Critical Mass Laboratory
CODEDACS	Component Development Data Acquisition and Control System
CPU	central processing unit
CRBR	Clinch River Breeder Reactor
CRL	Central Research Laboratories
DDACS	Distributed Data Acquisition and Control System
DF	decontamination factor
DIPRES	direct press spheroidized
DOE	U.S. Department of Energy
DOG	dissolver off-gas
EPN	external point name
ETC	Environmental Test Chamber
FRD	Fuel Recycle Division
F.R.G.	Federal Republic of Germany
FFTF	Fast-Flux Test Facility
GCA	Geophysics Corporation of America
HEDL	Hanford Engineering Development Laboratory
HFIR	High Flux Isotope Reactor

HRLEL	High Radiation Level Examination Laboratory
HTGR	High-Temperature Gas-Cooled Reactor
IAEA	International Atomic Energy Agency
I&C	Instrumentation and Controls Division
IBM	International Business Machines
IET	Integrated Equipment Test
IPD	Integrated Process Demonstration
LFVSS	Low-Flow Ventilation System Simulation
LMR	liquid metal reactor
M&C	Metals and Ceramics Division
MSTA	Maintenance System Test Area
NDD	*n*-dodecane
NEMA	National Electrical Manufacturers Association
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
PaR	Programmed and Remote Systems
PC	personal computer
PCM	process control module
PNC	Power Reactor and Nuclear Fuel Development Corporation
PNL	Pacific Northwest Laboratory
R&D	research and development
RDS	Remote Disassembly System
ROMD	Remote Operation and Maintenance Demonstration
SCR	silicon-controlled rectifier
SETF	Solvent Extraction Test Facility
SETCO	Standard Electrical Tool Company
SMS	Subcriticality Measurement System
SRL	Savannah River Laboratory
TBP	tributyl phosphate
U.K.	United Kingdom
UKAEA	United Kingdom Atomic Energy Authority
WINCO	Westinghouse Idaho Nuclear Company
XRF	X-ray fluorescence

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