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Consolidated Fuel Reprocessing Program Progress Report for Period January 1 to March 31, 1986

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CONSOLIDATED FUEL REPROCESSING PROGRAM PROGRESS REPORT FOR PERIOD JANUARY 1 TO MARCH 31, 1986

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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

W. D. BURCH

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

Tests and evaluations of the United Kingdom (U.K.) solid-bowl feed clarification centrifuge have been completed. An improved drag bushing made of ZrO_2 provides an extended service life. Successful demonstration tests have been performed using water and Fe_2O_3 powder for three types of operation: (1) the processing of a single digester batch of dissolved driver fuel at a bowl speed of 20,000 rpm, (2) the processing of seven digester batches of blanket fuel at 20,000 rpm, and (3) an entire 30-d campaign as a final polishing centrifuge at 10,000 rpm.

A pulsatile fluidic pump and head-tank delivery system for the Integrated Equipment Test (IET) clarification centrifuge has been successfully demonstrated and turned over to IET operations personnel for routine use.

Tests of a double overhead condenser system on the IET rotary dissolver indicate that iodine will pass through to the off-gas treatment system. Only ~4% of the iodine fed to the system was recycled to the dissolver. A poor material balance indicated that iodine was accumulating in the system, although not in the liquid inventory. Additional tests are planned.

Detailed evaluations of the effects of aqueous vane length on centrifugal solvent extraction contactor performance are complete.

Mass transfer efficiency tests using uranium in single-stage and two-stage prototype 5.5-cm-diam contactors show stage efficiencies ranging from 93% to 100% for both extraction and stripping.

Four- and eight-stage prototype contactor modules are being upgraded by balancing rotors and providing new drive motor mounts that maintain motor-rotor alignment. The contactor reliability test stand functions are being checked out, and integration of the test stand with Integrated Process Demonstration (IPD) processes is under way. Operation with uranium on a continuous basis is expected in about six months.

Twenty-seven Fast-Flux Test Facility (FFTF) test pins have been fabricated at Hanford Engineering Development Laboratory (HEDL) using direct press spheroidized (DIPRES) feed material. These are scheduled for use in cycle 9, which will be loaded into the reactor this summer.

1.2 ENGINEERING SYSTEMS

M. J. Feldman

Installation of the advanced servomanipulator (ASM) in the Advanced Integrated Maintenance System (AIMS) has been completed. This included the interface package and television cameras on the transporter, the ASM and hoist on the interface package, the ASM control system on the transporter, and the ASM master arms in the AIMS control room.

Wiring for the manipulator transporter has been completed, and the transporter is operational.

The experimental portion of the force/nonforce experiment using the model M-2 servomanipulators was completed, and data are being evaluated.

The design of a test stand for the manipulator tests was completed. This is a joint effort with the Power Reactor and Nuclear Fuel Development Corporation (PNC) of Japan. Duplicate stands will be built and tested in each country, and a comparative test program will be conducted.

1.3 IET FACILITY OPERATIONS

O. O. Yarbro

Work in the IET operations centered on preparations for the integrated campaign scheduled for April. The solvent extraction system was operated continuously over a 4-d period. This operation confirmed that switching the roles of the feed makeup and feed tanks improved process operations and provided the capability to process feed with higher heavy metal concentration through the accountability and feed makeup systems. This short-term run also provided the safeguards group with an opportunity to apply the heavy metal inventory surveillance software to the modified equipment.

A fluidic pump was installed for transferring solution from the centrifuge feed tank to the centrifuge. The major portion of the installation required locating a tank containing the fluidic pump at the proper elevation and adding a newly designed flow-smoothing tank to collect the solution prior to feeding the centrifuge.

Construction of the Environmental Test Chamber (ETC) was completed in March.

1.4 STRATEGIC PLANNING AND ANALYSIS

J. G. Stradley

A technical specialist meeting was held in Japan to review the current status and develop future plans for the Joint Criticality Data Development Program. A total of 28 critical experiments have been completed at the Pacific Northwest Laboratories (PNL) Critical Mass Laboratory (CML) on the program.

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 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, and 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 ASPEN Simulation of Fuel Reprocessing Flowsheet

B. E. Lewis

Brief descriptions have been prepared for each of the 128 FORTRAN blocks and subroutines used in the ASPEN simulation for the Breeder Reprocessing Engineering Test (BRET) process material balance. The descriptions include the FORTRAN block or subroutine name, the system name in which the routine was called, the ASPEN stream numbers on which it operates, and a brief outline of its function.

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

The inleakage of air to the dissolver steam chest, caused by misalignment of the faces of the large flange that joins the discharge chute to the steam chest, was reduced to an acceptable level by installing a new corrugated gasket. Several other air leaks were also either eliminated or reduced significantly. The total inleakage is now at an acceptable level.

Plans for installation of a heavy-duty gear reducer in the dissolver drum train as well as the installation of a replacement drum support roller shaft have been deferred. Near-term operation of the dissolver is not jeopardized by these actions, and if a need should develop, the parts can be installed without a significant delay.

Criteria were established for the development of hardware and/or software that controls dissolver drum rotational speed and direction for proper interstage transfer of solids.

2.3 SPECIAL CHEMICAL SYSTEMS DEVELOPMENT

B. E. Lewis

Special chemical systems include all R&D efforts on feed clarification centrifuges, fluidic pumps and other devices, 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 line.

2.3.1 Centrifuge Development

J. G. Morgan

Tests and evaluations of a solid-bowl centrifuge (U.K. design) have been completed along with an investigation of improvements for the drag bushing to increase its life. The reference breeder fuel reprocessing flowsheet (0.1 metric ton/d) specifies a primary centrifuge for removal of the insoluble material from a batch of dissolver fuel solution in a digester tank every 16 h. Driver fuel will contain ~500 g of undissolved solids per 16-h batch of fuel, which is enough solids to fill one U.K. centrifuge bowl. It is estimated that blanket fuel will contain ~70 g of undissolved solids per 16-h batch of fuel solution, allowing seven batches of fuel to be processed in one centrifuge bowl. Both these modes of primary clarification have been successfully demonstrated using Fe_2O_3 powder in water and bowl speeds of 20,000 rpm. The newly developed (ORNL) zirconium oxide bowl bushing was fitted to the centrifuge bowl and operated satisfactorily.

An aqueous feed clarification step has also been specified just prior to the first solvent extraction cycle. This polishing centrifuge will operate at 10,000 rpm continuously during a 30-d campaign. With the use of small additions of powder to the water feed, the centrifuge was operated for 30 d with no measurable wear of the zirconium oxide bushing. Acceptable clarification efficiencies were achieved in both the primary and polishing clarifier applications.

A final quantitative vibration analysis was obtained on the solid-bowl centrifuge under both static and dynamic operating conditions. At 10,000 and 20,000 rpm the amplitudes of critical vibration frequencies were low. Below 10,000 rpm several rather larger amplitude peaks were recorded, supporting the operational procedure of quickly bringing the bowl speed up to 10,000 rpm on startup.

2.3.2 Fluidics R&D

J. G. Morgan and W. D. Holland

A demonstration test was completed incorporating a pulsatile fluidic pump supplying primary dissolver feed solution to the IET clarification centrifuge. The fluidic pump was mounted in a thimble beneath the feed tank, delivering the uranyl nitrate solution ~18 ft vertically to a small head tank. From the head tank, the solution flowed by gravity to the centrifuge. A fairly constant flow of ~4 L/min was maintained satisfactorily. This equipment is now operated as an integral part of the IET head-end process.

2.3.3 Other Special Chemical Systems

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

A preliminary analysis of the data from the initial dissolver off-gas (DOG) double overhead condenser tests has been 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. The data indicate that an average of ~4% of the iodine fed to the off-gas is recycled to the dissolver. However, the data also show that ~26% of the iodine accumulated in the system (but not in the liquid inventory). Additional experiments have been planned to better quantify the accumulation.

A preliminary study of one concept for a solids-loading monitor for the U.K. clarification centrifuge has been completed. It appears that radiation sensors will be satisfactory for use with the primary centrifuge. Three sensors are necessary to reduce the uncertainties caused by the exact activity of the fines and the background radiation level. It is not clear that this technique is viable for the polishing centrifuge application because the activity of the fines may be too low to allow a reasonable discrimination from background. A report on the recommended design for the radiation-detector-based solids inventory monitor is in preparation.

A preliminary design for a steam stripper that will recover *n*-dodecane (NDD) from a stream containing small amounts of tributyl phosphate (TBP) has been completed. A cost estimate for the experiment is in preparation. Initially, there were concerns about the potential cost of waste processing for the experiment, but the ORNL Department of Environmental Management has granted permission to discharge the wastewater stream containing trace amounts of TBP (3 to 5 μg/mL) and NDD (100 to 150 μg/mL carbon) to the process drains, thus eliminating any liquid waste processing costs.

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 maintain awareness of efforts at PNL to document ion-implantation development and to monitor storage specimens.

2.4.1 Off-Gas Treatment Systems

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 has been evaluated using information from IET Iodox material balance flowsheets. New enthalpy calculational routines have been added, and excellent agreement has been obtained between the hand calculations made during the design phase of Iodox and the new computer code results.

Test plans for preliminary testing of both NO_x columns in the IET have been prepared.

Two abstracts for papers were accepted for presentation at the 19th Nuclear Air Cleaning Conference. The first paper will detail the operation of the integrated IET off-gas system and will give particular attention to iodine transport. The second paper will focus on the performance characteristics of the packed NO_x scrubbing tower.

2.5 SOLVENT EXTRACTION PROCESS DEVELOPMENT

R. T. Jubin

2.5.1 SETF

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

A tenth major solvent extraction campaign in the Building 7920 mixer-settlers is under way using high-burnup FFTF fuel, which is on hand. The recovered plutonium will be converted into PuO_2 by oxalate precipitation, which is a product suitable for return to HEDL. Objectives for this campaign are to further explore reference and alternate solvent extraction flowsheets using in-line process control with a feedback loop. Results should be available for the next quarterly report.

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 further the understanding and knowledge level of contactors by performing specific tests and evaluations in the laboratory and through the use of descriptive computer models.

The Westinghouse Idaho Nuclear Company (WINCO) work involves the design and fabrication of a stainless steel four-stage contactor and a plastic single-stage unit. The current concepts indicate that the stainless steel housing can be fabricated without the use of inserts and that the overflow ports can be machined without drilling through the entire block and plugging the external holes (as was done in the ORNL four-stage unit). In addition, each stage will have removable bearing and drive motor subassemblies; these should provide for simpler fabrication and are compatible with the industrial concept of using

motorized spindles. The new spindle design includes provisions for air purge, vessel off-gas connections, and a seal below the bearings to prevent vapors and aerosols from reaching the bearing subassembly. The design package for the contactors has been completed, and the drawings are undergoing both internal and engineering review. A meeting with WINCO personnel to discuss the design was held in March.

Detailed evaluations of the effects of aqueous vane length on contactor performance are complete. These tests demonstrated extreme sensitivity of the rotor performance to aqueous vane length by showing capacity variations of up to 50% depending on the length of the vane. It is critical that the vane extend to at least the edge of the weir for optimum throughput.

A manometer has been installed on the single-stage ORNL contactor to study the liquid height in the annular mixing zone.

A concept for an add-on purge-air system suitable for all future contactors regardless of the chosen drive system has been developed. This design utilizes a modified motor mount for the prototype rotor with narrow annular gaps at the shaft/housing and flywheel/housing positions. In addition, a blower is provided to force air from the plenum below the motor/bearing assembly across the rotor top/balance wheel region and down toward the aqueous collector ring and off-gas port. The concept is currently being evaluated for a potential patent.

Work has continued to define a possible series of joint experiments with Savannah River Laboratory (SRL) to demonstrate plutonium and uranium coextraction, partitioning, and stripping in centrifugal contactors. The final set of flowsheets intended to specify test conditions is completed. The final draft of the test plan should be completed next quarter.

Uranium mass transfer efficiency testing of the two-stage prototype 5.5-cm-diam unit continued. The test results indicate stage efficiencies >95% for both extraction and stripping of uranium. The O/A ratio selected for each test was based upon achieving an extraction factor of ~1 for the available feed solution and avoiding any pinched conditions.

Uranium mass transfer efficiency testing of the single-stage prototype unit was begun. The goal of the single-stage testing is to develop the mass transfer efficiency envelop for the range of rotor speed, flow rate, and O/A within the hydraulic envelop. At an O/A of 1, measured efficiencies to data have ranged from 93% to 100%.

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 5.5-cm-diam 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; complete modifications and installation of a spare IET contactor to investigate a surge overflow concept; and provide assistance to IET operations, as required.

2.6.1 Prototype Contactors

L. D. Ladd and P. A. Haas

As discussed previously. performance testing of the prototype 5.5-cm-diam centrifugal contactors over the full range of design conditions could not be accomplished because of excessive vibrations. The vibrations were determined to be a result of (1) fabrication misalignment, which led to an inability to properly balance the motor/rotor assemblies; (2) design deficiencies in the motor mount that must maintain proper alignment; and (3) poor quality drive motor bearings. Rotors from the two- and four-stage units were reworked sufficiently to permit operation at the design speed without noticeable vibration, but when installed in the contactor housing, motor-mount alignment problems became evident. The motor mounts were redesigned, and new ones are being fabricated. The drive motors supplied with the contactors are not acceptable for long-term applications, but they will be adequate 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 rotor design effort has been initiated that will carefully consider and incorporate fabrication procedures that will result in a well-aligned and balanced rotor. Two prototype rotors will be fabricated and tested to verify the design concepts, after which a complete set of replacement rotors will be procured.

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 prototype 5.5-cm-diam centrifugal contactors provided by SRL. Shakedown of the facility was initiated using the eight-stage bank of contactors as received from SRL. Currently, efforts are under way to proceed as quickly as practicable with integration of the test stand into IPD to permit operation with uranium in the system. The two- and four-stage contactor modules will be added to permit operation with a complete solvent

extraction cycle, and the eight-stage contactor will be upgraded. The modifications are expected to require about six months.

2.6.3 IET Solvent Extraction System

S. P. Singh and J. F. Birdwell

A surveillance program was initiated to monitor the vibration level of the drive units of the IET centrifugal contactors to determine if incipient bearing failures could be detected. Current indications are that the drives on the 8-2 bank of contactors can be expected to operate at least 7000 h without failure of the bearings. The 8-1 bank can be expected to operate at least 2000 h, with the exception of the stage 16 drive, which is predicted to have only ~1000 h of useful life. This drive was removed and a spare was installed to provide greater reliablity.

Nosepiece protector devices were installed on the 8-1 drive units about a year ago to provide corrosion protection to the exposed carbon steel spindle components. These devices also serve to distribute the purge air flow uniformly and, thus, significantly enhance its effectiveness. Nosepieces have been fabricated for installation on the 8-2 drives in the near future. The failed 8-2 spindle, which was described previously, was returned to the factory for rebuilding.

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 remaining irradiated FFTF fuel has been sheared and transported either to the SETF for two experiments this year, to the hot cells at Building 2026, or to retrievable storage. The old equipment in the hot cell and the fuel solutions remaining from previous experiments have been discarded.

The French have reported the release of ruthenium, perhaps as dust, from dried breeder reactor fuel cladding. This resulted in problems with high activity on absolute filters and increased the radiation exposure of workers. In tests at ORNL, cladding from FFTF fuel with a burnup of ~90,000 MWd/metric ton retained, after dissolution of the fuel in nitric acid, ~50% of the ruthenium initially in the fuel. One piece of the FFTF cladding was rinsed with methanol to remove loose material and then shaken vigorously with 12–28 mesh, humidified silica gel (chosen as an abrasive powder). The gross gamma count (by an in-cell monitor) of the cladding was reduced ~25%; this amount of the ruthenium probably could have become airborne under agitation. This piece of cladding plus five others that had not been abraded were leached with 8-*M* HNO_3 at 100°C for

5 h; the gross gamma count of the cladding was reduced by ~45%, and the weight of the cladding was reduced by 1.6%. Leaching with 8-*M* HNO_3—0.1-*M* F^- for 5 h at ~60°C reduced the gross gamma count to ~45% of the initial count while dissolving an additional 6.9% of the cladding. The cladding was then dissolved using 4-*M* HCl for 5 h at 100°C; a small amount of finely divided black material remained. The gross gamma count of the black residue was ~20% to 30% of the initial value, indicating that a significant quantity of ruthenium was insoluble in HCl (the activation products of stainless steel should have dissolved). All the leach solutions will be submitted for uranium, plutonium, and gamma-active fission product analytical determination.

2.8 CONVERSION PROCESS DEVELOPMENT

W. S. Groenier

The Building 3019 Interim Mixed Oxide (MOX) facility is being maintained in standby condition, and the fabrication of test pins at HEDL for an irradiation confirmation test of DIPRES feed material in the FFTF has been completed.

2.8.1 DIPRES Engineering Studies

L. Rice and D. E. Rasmussen (Hanford Engineering Development Laboratory)

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

All work is now complete. Twenty-seven test pins have been fabricated, inspected, and transferred to FFTF experimenters. The pins are currently scheduled to be loaded into the reactor this summer for the cycle 9 irradiation.

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 prototype equipment for breeder reprocessing facilities. The combined process equipment and characteristics of these components and systems will be tested in the IET facility as well as the Maintenance Systems Test Area (MSTA).

Beginning in FY 1986, the Component Development portion of Engineering Systems was transferred to Process Engineering R&D (see Sect. 2). The efforts of Engineering Systems are concentrated into three tasks (disassembly and cutting systems, special remote systems, and remote control engineering) and the Program Office for Remote Technology.

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 (shear) 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 remote operation and maintenance of a prototype system. A prototype mechanical head-end system consisting of a laser-disassembly system, a shear system, and an overall control system was installed in the Remote Operations and Maintenance Demonstration (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

The high-water-base fluid leak in the shear actuators experienced late last quarter was repaired, and the remote shear system was returned to service. Two additional prototype light water reactor (LWR) fuel bundles for the April IET integrated run were sheared to verify adequacy of the bundle design. The planned operational and fuel-handling scenarios were followed to determine their adequacy. The activities necessary to prepare the shear and feed systems for the April IET run have been identified and scheduled. Technician training in shear system operation is continuing.

Repair of the electrical malfunctions in the laser generator was completed, and the equipment is operating. Difficulty is being experienced in achieving the desired laser beam size at the high power setting needed for crop-cutting of the synthetic liquid metal fast breeder reactor (LMFBR) fuel. Techniques for beam size reduction are being explored.

The draft test plan for the remote maintenance of the remote disassembly system was issued on schedule at the end of March.

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 or by other tasks in the CFRP are being developed by this task group. During FY 1986, these tasks 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, 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, a test report describing the results of these handling tests was prepared, and it is currently undergoing internal review. This report also documents the results of mechanical tests performed during earlier periods on the Connector Environmental Test Stand.

Also during this period, the design of a Manipulator Test—Test Stand, which contains a variety of small but common reprocessing equiment items, was completed. The development of this stand is a cooperative effort between the CFRP and PNC, and the stand, and a duplicate to be fabricated and tested in Japan, will contain both U.S. and Japanese equipment items.

3.2.2 Cell Transporter

D. Macdonald

The transporter supports and provides mobility to the in-cell servomanipulators; it consists of a bridge, a trolley mounted on the bridge, and an externally telescoping rigid mast mounted on the trolley. The advanced servomanipulator package is then attached to the lower end of the rigid mast assembly.

During the previous reporting period, the transporter was installed in Building 7603, acceptance testing was performed, and several minor problems were identified. All problems except one were corrected, and the unit was turned over to the Remote Control Engineering Task for installation of the interface package and advanced servomanipulators. The one remaining problem is with the carriage hoist motor. The brakes remain engaged while the motor is operated. The solution to this problem is currently being discussed with the Harnischfeger Corporation.

3.2.3 Equipment Racks/MSTA

R. W. Mouring

In previous periods, equipment racks were designed, fabricated, and installed on support structures in the MSTA. The area was also modified to locate the racks in the proper orientation to the maintenance equipment. Tie-in of the rack's piping system to the simulated penetration plugs was completed, and the final design and fabrication report is in preparation.

3.3 REMOTE CONTROL ENGINEERING

J. N. Herndon

3.3.1 Manipulator and Maintenance System Development

J. C. Rowe, D. P. Kuban, E. C. Bradley, C. T. Kring, M. W. Noakes, S. D. Zimmerman, R. F. Spille, R. C. Muller, and S. M. Killough

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 future demonstrations for remote handling applications. Key features to be demonstrated in AIMS include: (1) modular remote maintainability of manipulator slave arms, (2) improved operational flexibility through modern digital control techniques, (3) servo-control 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 major program milestone for installation of the AIMS components by Feb. 28, 1986, was met. Some of the significant accomplishments in meeting this milestone included (1) assembly and installation of the interface package and planar camera positioners, (2) installation of the ASM arms on the interface package, (3) repackaging and installation of the slave arms and interface package controls on the transporter, and (4) assembly and installation of the transporter controls. The three interface package cameras were installed as were the two facility and two transporter cameras. All conduit, cabling, and terminations that tie together all the control racks and hardware and the facility power connections were completed. The AIMS slave arms and interface package should be operational by the end of April.

A formal effort in commercialization of the ASM system has begun during this quarter. The approach is based on two objectives: (1) to transfer the current ASM technology to a commercial vendor and (2) to separately pursue a cooperative agreement to produce an improved version of the ASM. The commercialization plan, which was drafted and is under review, includes a schedule for planned activities to conclude an agreement with the commercial vendor before the end of FY 1986.

3.3.2 Studies and Evaluations

J. V. Draper (Clarke Ambrose, Incorporated), B. S. Weil, and W. E. Moore

The experimental section of the force/nonforce experiment using the M-2 servomanipulators in ROMD was completed during this quarter. The purpose of this testing program is to investigate the relative performance of manipulator operators with varying levels of force reflection while performing realistic remote handling tasks. Analysis of the data is continuing. Data to be analyzed include time used for task performance, errors committed, forces exerted on the task, manipulator joint velocities, joint currents, and end-effector accelerations.

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 synergistic testing of process equipment and flowsheets prototypic of a pilot-scale fuel reprocessing plant and to test 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 prototypic of those intended for deployment in an advanced fuel reprocessing facility.

Work during the quarter centered on preparations for the integrated campaign scheduled for April. These preparations included continuous operation of the solvent extraction system during a 4-d period.

Successful operation of the solvent extraction and supporting systems was completed. The operation confirmed that the reconfiguration of the feed makeup and feed tanks improved process operations and provided the capability to process feed of high heavy metal concentration through the accountability and feed makeup systems. This short-term run also provided the safeguards group with an opportunity to apply the heavy metal inventory surveillance software to the modified equipment.

The gadolinium monitor stability test, in which the monitor was operated for about 490 h, was completed. The monitor output signal was stable throughout the entire period, which began last quarter.

The experimental runs for characterization of the hulls wash/dry station were completed, and the resulting data are now undergoing analysis.

The minor problems identified while operating the acid concentration portion of the Iodox system in December 1985 were resolved, and the system is ready for further testing.

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 force-reflection evaluation test program was initiated and completed on schedule. Evaluation of the utility of servomanipulator force feedback in performing remote handling tasks is the primary objective of this experiment, which involved rigorously controlled test conditions and extensive data collection. Test operations with the M-2 servomanipulator began in the first week of January and continued through the first week of March. The experimental design included 3 force feedback conditions, 4 remote handling tasks, controlled viewing, 6 test operators, and 15 test sessions per operator. Utilizing a computer-based data acquisition system, the staff recorded data recorded and archived them on magnetic tape. These data include manipulator slave joint velocity and current, slave arm acceleration, six-axis task loading, task completion time, and critical incidents. Preliminary review of the task completion time and critical incidents data, averaged across operators, shows consistent patterns of performance for each of the force feedback conditions administered. The remote control engineering group is developing data-manipulating routines for review and evaluation of the stored data.

During the remainder of the quarter, efforts were directed to ROMD equipment maintenance and informal testing with the M-2 servomanipulator. Experimental methods for direct measurement of servomanipulator force feedback characteristics were investigated to aid in developing formal test plans for the M-2 and advanced servomanipulators.

4.2 IET ENGINEERING

W. W. Evans

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 ETC

B. B. Spencer

Construction of the ETC was completed in March, thus fulfilling the requirements of the attendant award fee milestone. Beneficial occupancy of the facility was assumed in the fourth week of March, and acceptance tests were initiated.

The cell atmosphere conditioning unit was tested in the fabricator's plant. Tests revealed probable inadequacies in the reheat coil. The unit was received and installed in March. If the steam coil is proven undersized as suspected, limited operations can continue until the coil is replaced.

Test plans have been written covering the acceptance/performance tests of the air conditioning unit and the functional checkout of the gas analyzers.

4.3 INSTRUMENTATION AND CONTROLS (I&C) SUPPORT TO IET

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

4.3.1 Distributed Data Acquisition and Control System (DDACS)

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

The effort to automate the solvent extraction feed adjustment tank is 95% complete and will be ready for use in the April campaign. Most of the software has been tested in the process controller by running against simulated process signals.

The portion of the Archival program that is located on the DDACS host computer was improved and now completes functions in 10% to 20% of the time previously required.

Preparation of the data bases for the ETC is 95% complete.

4.3.2 Component Development Data Acquisition and Control System (CODEDACS)

M. S. Hileman and R. G. Upton

One problem was experienced with the CODEDACS hardware system during the quarter. The problem was traced to a failed flat ribbon cable in the main disk drive and

was corrected by local Instrumentation and Controls Division (I&C) maintenance personnel.

4.3.3 IET Process Equipment Instrumentation

J. A. Hawk and R. E. Hutchens

Turbine flow meters and associated instrumentation were installed in the recycle acid and water lines to 11F03. The flow meter instrument signals were tied into DDACS to provide a measurement of total volume of acid and water addition to 11F03.

A conductivity monitor for tank 11F03 has been installed and checked out, and a temperature sensor has been installed in recycle acid tank 90F29.

4.4 IET PLANNING

J. H. Shaffer

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

Planning activities have been directed toward preparations for the next major IPD integrated campaign scheduled for April 27–May 2, 1986. This campaign will, as a milestone objective, demonstrate the integrated operation of the remote shear system with the rotary dissolver using simulated fuel rods containing uranium dioxide pellets in zircaloy tubing. The campaign was concurrently scheduled for direct support of the CFRP Safeguards Workshop. The IPD operations will provide realistics tests for applications of materials accountability procedures and will perform simulated diversions of nuclear materials for tests of advanced safeguards methods.

An experimental IPD campaign was scheduled for the period March 23–27, 1986, to accommodate engineering development tests and to provide for preliminary examination of revised safeguards accountability procedures that will be demonstrated for the CFRP Safeguards Workshop. The experimental campaign also provides the first demonstration of the fluidic pump developed by the CFRP in a routine plant service application. Details for this campaign were developed into a test plan, and test instructions for conducting the IPD operations were prepared.

A draft summary of IET facility operations during FY 1985 was prepared for publication as an ORNL technical memorandum report.

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 the foreign exchange activities, and support in specialized technical areas.

5.1 STRATEGIC STUDIES

B. E. Prince

A study that reviewed the economic aspects and issues involved in applications of the plutonium fuel cycle in LWRs and fast breeder reactors (FBR) is being documented. The study was an analysis of the relationships governing the relative costs of various fuel cycle options, including once-through LWR cycles, uranium and plutonium recycle in LWRs, and plutonium cycles for modular-designed LMRs. The significance of the scale of economics in fuel cycle service costs is discussed in the report as is the logic for assessing the economic value of plutonium during various phases of industry development.

5.2 FOREIGN EXCHANGE AGREEMENTS

The CFRP has active agreements with the Commissariat à l' Energie Atomique (CEA) of France, PNC of Japan, and the United Kingdom Atomic Energy Authority (UKAEA).

5.2.1 U.S./CEA Exchange

Planning is under way for a technical specialists meeting to be held in the United States in May 1986.

5.2.2. U.S./PNC Exchange

In the Remote Systems Technology area of the exchange (see Sects. 3.2 and 3.3), review comments were incorporated into the report describing the comparative testing of the Japanese BILARM 83A power manipulator, the U.S. M-2 servomanipulator, and the Programmed and Remote Systems (PaR) 6000 power manipulator. The report describing the testing program in the United States on the PNC high-definition TV system was issued for comment. Work continued on the design of a manipulator test stand to be built in each country for use in establishing the performance of various manipulators.

In the Joint Criticality Data Development area, a technical specialist and annual administrative review meeting was held in Japan in March 1986. Eleven critical experiments were performed at the PNL CML during the quarter, thus bringing the total performed to 28 of the 77 required by the program. The Subcriticality Measurement System (SMS) nuclear verification experiments were completed and established complete acceptability of the system performance. The dynamic solution-draining experiments utilizing a cylindrical tank containing highly enriched uranium nitrate solution were initiated and completed. The solution was drained and the k-effective established as a function of the solution remaining in the tank. The measured k-effectives, which were obtained in a time frame of seconds, ranged from 0.9 to 0.3.

5.2.3 U.S./UKAEA Exchange

This exchange 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 U.S. fiber-optic spectrophotometry equipment was shipped to the UKAEA for installation in the Dounreay FBR reprocessing plant. Operational data will be collected through a jointly developed experimental plan.

Tests were completed on the centrifugal feed clarifier, which is on loan from the UKAEA. The equipment will be prepared for shipment and returned to the United Kingdom in June 1986.

Agenda topics continued to be considered for a joint control and instrumentation symposium involving technical specialists from each country. It is currently planned to be held in the United Kingdom during the summer of 1986.

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. Activities during FY 1986 on this task were limited to completing the evaluation started during FY 1986 of a gadolinium monitor installed in the chemical

makeup area of the IET. The monitor displayed negligible drift during the long-term stability tests—the major overall test performed during FY 1986. The results of the evaluation conducted in FY 1985 and FY 1986 are now being documented.

5.4 SAFEGUARDS ASSESSMENTS

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

The objective of this task is to assess the availability of appropriate safeguards technology for reprocessing plant application and to assess the safeguards implication of reprocessing plant design and operational features.

The current focus is on the development of advanced safeguards concepts for monitoring plant operations. A variety of process-monitoring techniques have been developed and tested in the primary uranium systems of IET. Sensitivity tests have been conducted to establish loss detection limits under various operational conditions, and these detection limits appear to be adequate for expected regulatory goals.

A demonstration of process-monitoring techniques for safeguards applications is planned during the IET April 1986 run. An integrated run of the IET will include unannounced removals of process solution to demonstrate the sensitivity of current process-monitoring software. A workshop is planned in addition to the demonstration to allow attendees an opportunity to discuss technical issues associated with process monitoring and to identify areas of future work.

An assessment is in progress to identify a process-monitoring concept that is feasible within the technical and institutional bounds of international reprocessing plant safeguards.

Abbreviations

AIMS	Advanced Integrated Maintenance System
ASM	advanced servomanipulator
BRET	Breeder Reprocessing Engineering Test
CEA	Commissariat à l' Energie Atomique
CFRP	Consolidated Fuel Reprocessing Program
CML	Critical Mass Laboratory
CODEDACS	Component Development Data Acquisition and Control System
DDACS	Distributed Data Acquisition and Control System
DIPRES	direct press spheroidized
DOE	U.S. Department of Energy
DOG	dissolver off-gas
ETC	Environmental Test Chamber
FBR	fast breeder reactor
FFTF	Fast-Flux Test Facility
FRD	Fuel Recycle Division
FY	fiscal year
FFTF	Fast-Flux Test Facility
HEDL	Hanford Engineering Development Laboratory
IET	Integrated Equipment Test
IPD	Integrated Process Development
LMFBR	liquid metal fast breeder reactor
LWR	light water reactor
MOX	mixed oxide

MSTA	Maintenance System Test Area
NDD	*n*-dodecane
ORNL	Oak Ridge National Laboratory
PaR	Programmed and Remote Systems
PNC	Power Reactor and Nuclear Fuel Development Corporation
PNL	Pacific Northwest Laboratory
R&D	research and development
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
WINCO	Westinghouse Idaho Nuclear Company

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