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Consolidated Fuel Reprocessing Program Progress Report For Period July 1 to September 30, 1986

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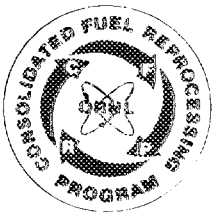

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CONSOLIDATED FUEL REPROCESSING PROGRAM PROGRESS REPORT FOR PERIOD JULY 1 TO SEPTEMBER 30, 1986

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Prepared for the
Office of Facilities, Fuel Cycle,
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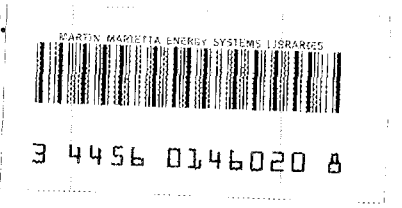

Contents

Foreword

The U.S. Department of Energy (DOE) sponsors all U.S. civilian research and development (R&D) on oxide 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 oxide 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

An analysis of data from the December and April Integrated Equipment Test (IET) facility runs with the dual overhead condensers and NO_x scrubber in the dissolver off-gas system shows little iodine recycle to the dissolver (~6% or less), NO_x removal ranging from 5 to 58% by the condensers, and essentially complete removal by the scrubber (effluent 1% or less).

Continuing centrifugal solvent extraction contactor development studies have shown (1) enhanced performance in the event of a stopped intermediate stage when using a new plenum housing; (2) a strong relationship between the liquid height in the annular mixing region and the rotor speed, total throughput, and aqueous vane length; (3) single-stage mass transfer efficiencies averaging 92% over a wide range of conditions for both extraction and stripping; and (4) an order-of-magnitude reduction in tributyl phosphate (TBP) content for aqueous streams cross-contacted with pure organic diluent at an aqueous:organic phase ratio of 100.

Prototype 5.5-cm-diam centrifugal contactors in two-, four-, and eight-stage arrays have been modified and installed in the IET test stand for automated and continuous operation.

1.2 ENGINEERING SYSTEMS

M. J. Feldman

The testing of the remote maintenance features for the shear system has been completed. All the components of the "in-cell" portion of the shear were remotely removed and then remotely reinstalled using a servomanipulator, cranes, and TV viewing.

Prototype electrical and fluid connectors have been installed on the U.S. version of the manipulator test—test stand (MTTS) and on the Japanese replica in Japan.

Skill test panels for master-slave manipulator operators were developed and tested. This equipment will be used in both the United States and Japan in programs comparing the performance of various manipulators using the MTTS. A high coefficient of correlation was obtained between operator skills and test results.

1.3 IET FACILITY OPERATIONS

O. O. Yarbro

The main emphasis this quarter was placed on preparing the Environmental Test Chamber (ETC) for operation, integrating the 5.5-cm-diam centrifugal contactors into the Integrated Process Demonstration (IPD) solvent extraction system, and completing the shear remote maintenance demonstration.

The ETC acceptance testing was completed. In addition, two experimental campaigns were performed demonstrating the pressure and temperature control and acid vapor removal concepts of the low-flow ventilation system.

The piping modifications to integrate the 14-stage centrifugal contactor rack into the IPD solvent extraction system were completed. Preliminary checkout of the process lines and equipment was initiated and will continue next quarter.

1.4 STRATEGIC PLANNING AND ANALYSIS

J. G. Stradley

A total of 41 critical experiments have been completed at the Battelle-Pacific Northwest Laboratories (PNL) Critical Mass Laboratory (CML) for the U.S. Department of Energy (DOE)/PNC Joint Criticality Data Development Program. The CML is currently undergoing physical upgrades that will prevent experiments from being conducted for a few months. A DOE/PNC Technical Specialists' meeting was held at ORNL in September 1986 to review the status of the development of technology associated with the Subcriticality Measurement System (SMS).

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 were 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 the 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. All of these objectives have been met.

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.

Efforts at Georgia Tech have continued in the following areas: (1) review and organization of information pertaining to the solvent extraction and electrochemical partitioning

of uranium and plutonium; (2) design, construction, and testing of an electrochemical uranium reduction cell; (3) operation of an eight-stage mini-centrifugal contactor bank; and (4) modification of the SEPHIS computer program to include a model for an interactive electroreduction cell.

2.2 CONTINUOUS DISSOLUTION METHODS EVALUATION

R. H. Chapman

This activity has continued the development and evaluation of continuous dissolution methods for nuclear fuel reprocessing. Objectives for FY 1986 were 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, and provide assistance to IET operations as required. These were completed.

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 were to complete the evaluation of the United Kingdom 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 evaluate various dissolver process options such as preheated liquid feed streams and double overhead condensers in the off-gas line. With the exception of the steam stripper tests, all objectives were accomplished.

2.3.1 Fluidics R&D

J. G. Morgan and W. D. Holland

The cyclic operation of the IET pulsatile fluidic pump is controlled using a three-way solenoid valve. It is desirable to locate the valve in a contact-maintained area to facilitate maintenance, but this would allow contaminated air from the pumping chamber to exhaust through a contact-maintained region of the reprocessing plant. Experimental work is under way to test an air control system that has no moving parts exposed to process fluids. The system utilizes a vortex amplifier in series with an air jet located in the process area, and two solenoid valves that would be located in a contact-maintained area. The pump and refill cycles can be controlled remotely by the solenoid valves. In addition, a vacuum can be applied during the refill cycle allowing a larger pump delivery when the level in the host tank is low. A disadvantage of this method is the larger air consumption compared to the

current method. A small commercially available air jet has been tested for use in the control system.* The jet is actuated during the refill cycle to apply a vacuum to the pump chamber, thus allowing faster refill times. A vacuum in the range of 3 to 27 ft of water was obtained when 10 to 30 psi air was applied to the jet. Because the refill time decreases exponentially with refill head, there is little incentive to go beyond 8 ft of water vacuum. About 3.2 scfm of air is required to actuate the jet with a vacuum of 8 ft of water and a jet exit orifice area of 0.038 $in.^2$.

2.3.2 Other Special Chemical Systems

B. E. Lewis, W. D. Holland, R. M. Counce, and E. L. Nicholson

Testing of a disk valve pump with ambient temperature water is continuing. The pump has been operated continuously in a recirculating mode for a total of ~636,600 pump strokes using a pump time of 1 s and a refill time of 2 s. The rate of wear on the valve disk and cage was found to be insignificant. This test has been repeated using an agitated solution of water and 0.1 g/L diatomaceous earth. About 520,000 pump strokes were achieved using a 0.4-s pump time and 0.6-s refill time. The pump was operated to allow a small release of air with each pump stroke to provide additional agitation to the solids in the bottom of the tank. Accurate weight measurements are planned to determine the degree of wear experienced by the pump. Visual inspection of the system indicated little or no deterioration.

2.4 AIRBORNE WASTE MANAGEMENT

R. T. Jubin

This activity includes all residual off-gas treatment efforts in the CFRP. Objectives for FY 1986 were 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, which is documenting ion-implantation development and monitoring storage specimens. The computer modeling work was deferred, but other objectives were accomplished.

2.4.1 Off-Gas Treatment Systems

R. T. Jubin and B. E. Lewis

Four papers were presented at the 19th DOE/NRC Nuclear Air Cleaning Conference which was held in August. Two of the papers focused on the NO_x scrubber system; one

*Penberthy Houdaille GH 1/2 B SST.

described the performance of the integrated dissolver off-gas system in the IET, including the dual overhead condensers; and one paper discussed the ETC.

The analysis of data from the December 1985 and April 1986 IET campaigns with the dual overhead condensers and NO_x scrubber is complete. Iodine recycle from the dual condensers to the dissolver ranged from 0.35 to 6.29%. The optimum operating temperature for the first condenser is in the range of 50 to 70°C with the second condenser operating at ~20°C. The results from these experiments generally were supportive of the equilibrium calculations made for the Breeder Reprocessing Engineering Test (BRET) conceptual design. The NO_x removal efficiency of the condensers varied from 4.79 to 58.3%, but was typically ~20%. The bulk of the NO_x removed by the condensers is believed to be from condensation of HNO_3 because the higher removal efficiencies usually occurred either near or during periods of low NO_x production (between fuel dissolution periods). The NO_x concentration of the effluent from the NO_x scrubber ranged from ~0.5 to 1.0%, which is supportive of the BRET design decision to omit the NO_x scrubber in a system with a dissolver off-gas NO_x concentration of ~1.0%.

2.5 SOLVENT EXTRACTION PROCESS DEVELOPMENT

R. T. Jubin

2.5.1 Contactor Development and Analysis

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

This activity has continued the development and testing of advanced centrifugal solvent extraction contactors. Objectives for FY 1986 were 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.

Work was completed on fabrication of an experimental advanced four-stage housing. Hydraulic tests of this unit began in mid-September and showed good phase separation by the weirs installed in the plenum for a stopped (dead) internal stage. This means that the adjacent stages do not have to handle the increased liquid burden as they must with the original horizontal overflow port design. Modifications are required, however, to realize similar performance when the dead stage is at the end of the cascade and to increase the total hydraulic throughput to the expected value.

An analysis of data collected on the height of the liquid in the annular mixing zone is being conducted. The data indicate that there is a strong correlation between the liquid height and both the rotor speed and the total throughput as would be expected, but they also show a third strong relationship with the aqueous vane length at the top of the rotor. The analysis is preliminary, but it appears consistent throughout the entire data set.

Uranium mass-transfer efficiency testing of the single-stage prototype 5.5-cm-diam contactor is complete. The exact effect of the phase ratio, flow rate, and rotor speed has

been quantified by the Statistical Analysis Systems' General Linear Model routine. The average efficiency throughout the range of test conditions was 92%. It was also determined that no significant difference existed between the extraction and stripping efficiencies throughout the range of test conditions.

A recently prepared test plan for demonstrating plutonium and uranium coextraction, partitioning, and stripping in centrifugal contactors has been modified to include the complete cleanup of all organic streams and to specify the total volume and concentration of aqueous feed and waste. Cascade steady-state response times were determined to calculate the total volume and concentration of each stream.

The preliminary results of a diluent wash test indicate that the aqueous TBP concentration can be reduced by an order of magnitude using four cross-current contacts with pure diluent at an organic/aqueous ratio of 0.01. The TBP-contaminated aqueous feed for the diluent wash was taken from the raffinate of a countercurrent four-stage uranium extraction run.

Limited mass-transfer efficiency testing of the four-stage prototype 5.5-cm-diam contactor is complete. The data indicate that a dead stage has the effect of reducing the overall cascade effectiveness by about one stage. Efforts are under way to model a cascade with a dead stage using the MATEX computer code.

2.6 SOLVENT EXTRACTION PROCESS EQUIPMENT DEVELOPMENT

R. H. Chapman

This activity continues the development and evaluation of prototype solvent extraction contactors. Objectives for FY 1986 were to procure mechanical drives for prototype 5.5-cm-diam centrifugal contactors; design, fabricate, and test new prototype rotors; complete modifications to the prototype contactors; complete installation of the contactor reliability test stand; complete modifications and installation of a spare IET contactor to investigate surge-overflow concepts; and provide assistance to IET operations, as required. The new prototype rotors have been fabricated for testing during the next quarter. Other objectives were accomplished.

2.6.1 Prototype Contactors

L. D. Ladd

Extensive modifications were completed to upgrade the two-, four-, and eight-stage modules sufficiently to operate at design conditions. Hydraulic testing of the various modules over the full range of operating conditions indicated acceptable performance by all three modules.

The drive motors supplied with the prototype contactors are not acceptable for long-term applications, but they will be adequate until replacement drives can be procured. A purchase order for new drives, which will be smaller versions of the high-quality milling machine spindles now in use on the 12-cm-diam IET centrifugal contactors, was placed.

Five motorized and five nonmotorized spindles (the latter will be driven with separate motors) will be procured for evaluation. Delivery of the spindle drives is expected late in the second quarter of FY 1987.

Design of an improved prototype rotor was completed. The design includes a number of simplifications and is based on fabrication procedures that will result in a well-aligned and balanced rotor. Two prototype rotors were fabricated and will be tested next quarter to verify the design concepts.

2.6.2 Contactor Reliability Testing

J. F. Birdwell, L. D. Ladd, and S. P. Singh

Modifications of the test facility that will be used for long-term testing of prototype 5.5-cm-diam centrifugal contactors were essentially completed with only some instrumentation and controls modifications remaining. The two-, four-, and eight-stage modules of 5.5-cm-diam centrifugal contactors were installed and integrated into the IET process system to permit operation of a complete solvent extraction system on a flowsheet representative of a small-scale reprocessing plant. Upon completion, the test facility will be extensively automated to permit unattended operation. Integrated operation of the test facility is scheduled to begin in the first quarter of FY 1987.

2.6.3 IET Solvent Extraction System

S. P. Singh

A purge air test on the 8-2 bank of 12-cm-diam centrifugal contactors in the IET was conducted to determine the status of the internal shaft seals at the top end of the spindles. The seals separate the weir control air and the purge air supplies. The test results confirmed that the seals are in good condition and that there is no mixing of the two air supplies.

2.7 ANALYTICAL CHEMISTRY DEVELOPMENT

D. A. Costanzo

2.7.1 X-ray Fluorescence (XRF) Development

J. M. Keller

The development of XRF as an analytical technique applicable to fuel reprocessing facilities was continued. An apparatus to support and align the X-ray tube and an optical bench with horizontal and vertical position control were designed, fabricated, and mounted on a table within a lead-lined containment box. The spectrometer optics were realigned, and the system was tested with the new high resolution position-sensitive detector and constant potential X-ray generator.

Preliminary results obtained with the old X-ray tube indicate an improvement in sensitivity and resolution with the system which was expected from operation of the X-ray tube at a constant potential relative to full-wave rectified potential.

Several candidates for a cell window were compared for acceptable transmission of uranium and plutonium L X-rays, resistance to chemical corrosion, susceptibility to radiation damage, and physical strength. Of the various materials compared, vitreous carbon, also known as glassy carbon, best meets the necessary requirements for a suitable cell window. Vitreous carbon has excellent chemical resistance (e.g., less than 1% weight loss when exposed to 92% nitric acid at 25°C for one month), is resistant to radiation damage, has acceptable physical strength, and has a low mass attenuation coefficient for the uranium (0.945 cm^2/g at 13.6 keV) and plutonium (0.839 cm^2 g at 14.3 keV) L X-rays.

About 51% of uranium L radiation was observed with a 2-mm-thick vitreous carbon window in front of a sample positioned with a 45° incident and take-off angle. This compares well to the predicted result of 56.5%. Similar results were observed for Sr Kα (a surrogate for Pu Lα), with 54% experimental vs 58.7% calculated.

3 Engineering Systems

M. J. FELDMAN

The scope of the work performed in the area of Engineering Systems includes the design, procurement, and development of prototypic equipment for breeder reprocessing facilities. The combined process equipment system, remote handling equipment, and the remote operation capabilities and characteristics of these components and systems will be tested in the IET facility as well as the Maintenance Systems Test Area (MSTA). The efforts of Engineering Systems are concentrated into three tasks (disassembly and cutting systems, special remote systems, and remote control engineering).

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. 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 beem installed in the Remote Operation 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

Development activities to establish parameters for laser crop-cutting of liquid metal reactor spent fuel assemblies were pursued during the period. A test model, having mostly reusable components, was designed, fabricated and used. Successful cuts were achieved with four distinctive sets of parameters.

The feed pusher drive, which failed during the April integrated run, has been modified to mitigate the causes of the problem and returned to service.

The remote maintenance testing of the Remote Shear System (RSS) was completed. The entire in-cell portion of the RSS was removed and replaced using the M-2 servomanipulator, ROMD crane, TV viewing, and "standard" hot-cell tools. Disassembly was accomplished in 10.5 d, and reassembly took 15.5 d, based on an 8-h work day. In only three instances was it necessary to provide manual assistance. These problems were minor, and it would require very little modification to conduct all these activities by remote operation.

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 at the ORNL are being developed by this task group. 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, MSTA, Building 7603, at ORNL has been prepared for testing components of the maintenance system.

3.2.1 Remote Connectors and Jumpers

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, the design and fabrication of an MTTS, which contains a variety of small but common reprocessing equipment items, was completed. The development of this stand is a cooperative effort between ORNL/CFRP and PNC. Identical stands are being prepared in both countries, and the stands will contain both U.S. and Japanese equipment items. The stands will be used to compare the performance of various advanced manipulator systems being developed in the United States and Japan. During this period, U.S. equipment items were shipped to Japan, and Japanese equipment items were received

from PNC. In addition, operator skill test panels were fabricated, and a procedure to measure the skill of the manipulator operators was prepared and validated. An instructional videotape was also prepared.

3.2.2 Cell Transporter

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

During previous periods, the transporter was installed in Building 7603, and acceptance testing was performed. In addition, resolvers and encoders for the bridge and trolley and side-guide rollers for the trolley were placed on order. The resolvers and encoders, in particular, are required to smooth out the bridge operation at low speed and to provide a signal for integration into the Advanced Integrated Maintenance System (AIMS) control system.

3.2.3 Equipment Racks/MSTA

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. During this period, a draft of the test instructions was prepared, and several maintenance tasks using the ASM were performed.

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, P. E. Arakawa, and D. C. Dunning

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 development 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.

Software development, system tuning, system demonstrations, and minor modifications were the main activities for the AIMS during this quarter. Several minor modifications were completed to improve master controller operability and maintainability. New master handle brackets were installed to allow repositioning of the master handles much nearer to the wrist pitch/yaw axes for more comfortable operation. This has resulted in much improved operability. Additionally, these brackets were made so that handles can be easily removed for maintenance and electrical cables were modified to facilitate this removal. The deadman switch function on the master handle was modified to ensure that the system is deactivated when released.

After completion of the modifications to the master controller arms, the ASM system was returned and exhibited significant improvement in overall stiffness and force reflection. Both wrists were tuned for all force-reflection ratios, and both upper arms have been tuned for the 4:1 ratio.

Six companies have expressed a desire to participate in the ASM commercialization negotiations. Negotiations with the six companies will begin soon.

The final version of the man-machine interface pendant controller used by the secondary operator for analog input to the AIMS control system is nearing completion. The main power printed circuit boards were received this month and have been assembled and checked out. Enclosures for the pendant have been fabricated, and parts are now being mounted in them. Development of new graphic display menus for controlling the AIMS system continues. A number of new menus have been created, and some of the old ones have been improved.

3.3.2 Studies and Evaluations

J. V. Draper, B. S. Weil, and W. E. Moore

Data collection for evaluation of the Manipulator Operator Skill Test (MOST) was completed in August. This test will be used to "calibrate" U.S. and Japanese operator skill levels for use in the MTTS collaboration with PNC. Analysis of these data indicates that the skill test, as administered, is capable of predicting operator's performance on remote handling tasks. Ten operators completed the test, and then they performed three repetitions of the electrical connector task used in the high-definition TV testing program. The MOST scores consisted of averages of time to completion of ten repetitions of the MOST task with a television camera in a "chest" position, five with the camera offset 45° to the right of the manipulator midline, and five with the camera 90° to the right of the midline. Multiple linear regression analysis found that a linear combination of the averages predicted average time to completion on the electrical connector task. The correlation between the linear combination and electrical connector performance was 0.98. (A correlation coefficient expresses the degree of relationship between two variables; correlations

range from −1.00 to 1.00, with high numbers indicating high degrees of relationship, and the sign indicating whether one increases with the other or decreases with the other.) This is very high and indicates that for this task the skill test performs very well.

Analysis of data from the force-reflection testing program is currently continuing. Data concerning the forces applied to the tasks have been included in the data set, and preliminary analyses were completed this quarter. It appears that force reflection has an impact on the ability of operators to (1) limit the amount of force applied to objects in the remote area, and (2) control the variability in the application of forces. Operators using force reflection exhibited lower maximum forces and more consistency in the application of force during testing; performance was best (on the force variables) with the 1:1 ratio and second best with the 4:1 ratio.

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 prototypical of a pilot-scale fuel reprocessing plant and testing advanced remote handling equipment and techniques. The IET facility consists of two distinct areas: ROMD and IPD. The ROMD area activities focus 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 and P. Welesko

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

Testing was completed for inventory verification and tank calibrations with lutetium spikes. The test consisted of adding a known amount of lutetium to the tank solution and carefully taking samples before and after the addition. These samples will be analyzed for a change in lutetium concentration from which the tank solution volume can be determined.

A test of the automated software module 1905 and the INTERFACE communications software module proved successful in transferring solution from 19F05 to 19F07. The software handled both the routine and nonroutine cases as described by the 1905 process operation diagram.

Considerable effort has been provided for the integration of the 5.5-cm-diam centrifugal contactors into the area. Assistance was provided on the procurement and installation of instruments and equipment. The data base for these new instruments is currently being created. A safety interlock software scheme utilizing both software and hardware interlocks was developed to monitor specific process variables in the new system for detecting possible abnormal events and to effect a system shutdown. The associated process and instrument diagrams have been updated. Preliminary checkout of the process lines and equipment was initiated this quarter and will continue through next quarter.

Documentation of the automation modules is continuing. Module 1905 is complete except for the software implementation diagram, which is currently being drawn. The final draft of the module 1907 process operation diagram is complete, and a rough draft of the 0923 process operation diagram is also complete.

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 remote maintenance demonstration of the RSS was completed. The in-cell portion of the shear was completely disassembled and then assembled using the Model M-2 servomanipulator, gantry bridge hoists, and various tools for verification of the system's remote maintenance design features and procedures and the establishment of maintenance times. A few of the remote maintenance tasks could not be demonstrated because the shear slide hydraulic actuator has been removed from the system for repair. The remainder of the maintenance tasks were successfully demonstrated with the exception of installing the slide assemblies' lower roller support modules, which need an improved alignment guide system. Maintenance operations were initiated at the beginning of the quarter and completed in September 1986.

Preparations for conducting the joint DOE and PNC manipulator comparative test program in ROMD have begun. Remote handling performance comparisons of the Model M-2 servomanipulator, the advanced servomanipulator, and two PNC manipulators are the primary objective of this test program. Reprocessing equipment remote maintenance tasks of both U.S. and Japanese design have been assembled on a test stand for manipulator operation under controlled conditions to provide the comparison data. Testing of the PNC

manipulators will be conducted in Japan using an identical test stand, tools, and test conditions. Preparation of test procedures are in progress. Test operations are scheduled to begin in ROMD using the M-2 servomanipulator in the first quarter of FY 1987.

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 Facility Engineering Support

W. W. Evans and E. L. Nicholson

The main emphasis this quarter was placed on preparing the Environmental Test Chamber (ETC) for operation and integrating the 5.5-cm-diam centrifugal contactors into the IPD solvent extraction system.

A considerable effort was required to seal the ETC to within the acceptable range for experimental testing. The interior walls of the ETC were painted to about 12 ft above the floor level with one coat of Amercoat 2490; three coats were applied to the concrete block walls at both ends. In addition, pipes and electrical conduits extending into the ETC were sealed and checked for leaks by using Freon and an ultrasonic sound-detecting device.

The piping modifications to integrate the 14-stage centrifugal contactor rack into the IPD solvent extraction system were completed. The arrangement to operate the rack in an automated and a continuous mode with the option to switch back to the 12-cm-diam contactors with a minimum of piping, electrical, and instrument changes will be checked as schedules allow. Checkout of the new rack equipment will be initiated next quarter.

The photometer control cabinet was moved into the IET control room from the IPD process ground-floor level in an effort to protect sensitive equipment from corrosive vapors. Only short sections of additional fibre-optic cable were required on each signal line as a result of this move. The efficiency of the cable with two splices in each loop was evaluated and considered satisfactory for relocation.

The computer software was modified to operate the IET automatic sampler at the new sample base station mentioned in the previous progress report. The sample line modifications were completed, and the system was checked out by Operations.

4.2.2 Environmental Test Chamber

B. B. Spencer

Acceptance testing of the ETC was completed. The power controller, which was used to feed the electrical resistance heaters for simulation of decay heat, was found to be inadequate and was replaced with a suitable unit. All items that were missing have been

provided by the construction contractor (e.g., orifice plates, valve trims). Calibration of the field sensors was completed, and correct operation of all remote actuators was verified. The control software was debugged and works satisfactorily.

Results of leak tests performed on the chamber showed that the inleakage rate was orders of magnitude greater than the target value of 1 L/min at 0.25 in. H_2O vacuum. Efforts to seal the chamber reduced the leak rate to ~6 L/min at the same pressure. Further reduction in the rate is desired but unnecessary for most testing scenarios because the intentional feed rate of air can be reduced.

Documentation provided with the air handling unit, under terms of the contract, was reviewed, and several items were found to be missing. Samples of material were removed from the unit and analyzed. Analysis showed that the materials of construction were not the material specified in the contract. The contractor was given the opportunity to correct the documentation package and to include the missing documents. Review of a second set of documentation revealed no significant improvement over the first set. Efforts are under way to terminate the contract.

Preliminary tests also indicated that the air handling unit does not perform to specification. It is possible to operate the ETC with the existing unit until contract difficulties are resolved, but it must be operated at a more narrow experimental range.

The ETC has been operated 24 h/d in two separate experimental campaigns. The first 75-h campaign successfully demonstrated the pressure and temperature control characteristics of the low-flow ventilation system. Pressure response to set-point changes was close to predicted patterns. A second campaign spanning a 91-h period demonstrated the predicted acid vapor removal mechanism associated with a low-flow system. These experiments have demonstrated the viability of the low-flow ventilation concept. Additional experiments are planned following a reworking of the air handling unit to obtain the full experimental range.

4.3 I&C SUPPORT TO IET

J. C. Suddath, J. A. Hawk,
M. S. Hileman, and R. E. Hutchens,

4.3.1 Distributed Data Acquisition and Control System (DDACS)

J. A. Hawk and M. S. Hileman

A continuing effort is ongoing in support of the process automation of IPD. This involved coding for the automatic transfer of 19F05 to 19F07 and some debugging.

Instrument loop sheets for interfacing DDACS with the addition of contactor test stand and the International Business Machines personal computer to IPD were completed.

4.3.2 IET Process Equipment Instrumentation

J. C. Suddath, J. A. Hawk, and R. E. Hutches

Modifications and new systems installations of the I&C systems in support of the ETC and the contactor test stand have accounted for the most of the support effort from the I&C Division support group. This includes some changes in the engineering unit ranges to free space for some of the new I&C systems.

Equipment problems with the PDP 11/44 computer continue to reduce the on-line time of Component Development Data Acquisition and Control System. A voltage regulator module was replaced by Digital Equipment Corporation maintenance for the second time in the PDP 11/70 to clear the problem with this system.

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 operations.

Currently scheduled activities for IET Operations beginning FY 1987 consist of programs that have long-standing milestones associated with their completion or represent commitments to other organizations. Two of these programs are major ROMD activities and consist of a remote maintenance demonstration on the remote disassembly system and the starting phases of a joint manipulator comparative test program with PNC. Tentative plans for IPD activities project the operation of the acid concentration and Iodox systems during FY 1987. However, scheduled activities are currently limited to those associated with beginning operations of the ETC and the installation and operation of the 5.5-cm centrifugal contactors in the IPD solvent extraction system.

5 Strategic Planning and Analysis

J. G. STRADLEY

Efforts described in this section provide a focal point for the foreign exchange activities and support in specialized technical areas.

5.1 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).

5.1.1 U.S./CEA Exchange

This exchange focuses on the area of Remote Systems Technology. A new task will focus on developing demonstrating an environmentally hardened remote control system for use with advanced manipulator maintenance systems.

5.1.2. U.S./PNC Exchange

In the Remote Systems Technology area of the exchange (see Sect. 3.2.1), components were exchanged between the United States and Japan for use on the manipulator test—test stand program. An identical stand was built in each country for use in establishing the performance of various manipulators. A Remote Systems Technology specialists' meeting was held in September 1986 at the ORNL.

In the Joint Criticality Data Development area, four critical experiments were performed at the PNL CML during the quarter, thus bringing the total performed to 41 of the 77 planned by the program. The CML is currently undergoing physical upgrades that will prevent any experiments from being conducted for a few months. A DOE/PNC technical specialists' meeting was held at ORNL in September 1986 to review the status of the development of technology associated with the SMS.

The DOE/ORNL and PNC continue to develop details of a broadened joint collaboration that will include all reprocessing topics.

5.1.3 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.

A joint control and instrumentation symposium involving technical specialists from each country was held July 29–31, 1986 at Harwell, United Kingdom.

Agreement was reached upon a jointly developed experimental plan for use with the U.S. fibre-optic spectrophotometry equipment, which has been installed in the UKAEA Dounreay Fast Reactor Reprocessing Plant for testing.

Testing of a UKAEA centrifugal clarifier was completed by ORNL, and the unit was returned to the United Kingdom..

5.2 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 the safeguards implication of reprocessing plant design and operational features.

The current focus is on the development of advanced safeguards concepts for for monitoring plant operations. Evaluation continued of the process monitoring data from the April 1986 integrated run of the IET. This evaluation was directed at understanding the performance of the software in place during the April run. Utilizing the results of the April 1986 run and other data, various elements are being developed of a process monitoring concept suitable for an international application of process monitoring to reprocessing plants.

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
DDACS	Distributed Data Acquisition and Control System
DOE	U.S. Department of Energy
ETC	Environmental Test Chamber
FRD	Fuel Recycle Division
HEDL	Hanford Engineering Development Laboratory
IBM	International Business Machines
I&C	Instrumentation and Controls
IET	Integrated Equipment Test
IPD	Integrated Process Development
METR	Man-Equivalent Telerobot
MOST	Manipulator Operator Skill Test
MSTA	Maintenance System Test Area
MTTS	Manipulator test—Test Stand
NRC	U.S. Nuclear Regulatory Commissin
ORNL	Oak Ridge National Laboratory
PC	Personal Computer
PNC	Power Reactor and Nuclear Fuel Development Corporation

PNL	Battelle-Pacific Northwest Laboratory
R&D	Research and Development
ROMD	Remote Operation and Maintenance Demonstration
RSS	Remote Shear System
SETF	Solvent Extraction Test Facility
SMS	Subcriticality Measurement System
TBP	Tributyl Phosphate
UKAEA	United Kingdom Atomic Energy Authority
XRF	X-Ray Fluorescence

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