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MARTIN MARIETTA

Consolidated Fuel Reprocessing Program Progress Report for Period October 1 to December 31, 1986

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MARTIN MARIETTA ENERGY SYSTEMS, INC.
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CONSOLIDATED FUEL REPROCESSING PROGRAM PROGRESS REPORT FOR PERIOD OCTOBER 1 TO DECEMBER 31, 1986

W. D. Burch, Program Director

W. S. Groenier
Manager, Chemical Process Development

S. A. Meacham
Manager, Remote Systems Development

J. G. Stradley
Manager, Strategic Planning and Analysis

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operated by
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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). A prime focus of present work is on technical exchanges and collaboration with other countries. In this context, the U.S. Department of Energy (DOE) is in the process of negotiating a major collaboration with Japan. Both work associated with the foreign exchanges and collaboration and some on-going work are reported in overview fashion in this series of quarterly progress reports.

1.1 CHEMICAL PROCESS DEVELOPMENT

W. S. Groenier

Preliminary criticality calculations for two proposed geometrically favorable continuous dissolver concepts indicate that the initial designs may be overly conservative. Additional calculations are under way.

Fluidic pump testing in the Integrated Process Development (IPD) facility has successfully demonstrated (1) the transfer of dissolver solution to the feed clarification centrifuge in the April 1986 campaign, (2) the complete emptying of a surge tank except for liquid fallback from the discharge line, and (3) performance with a uranyl nitrate feed solution at temperatures to near boiling.

Tests with the experimental centrifugal contactor show that the phase ratios in the couette region and rotor are not the same. Furthermore, they are both different from the ratio of flows impressed upon the contactor. These findings indicate that early assumptions in the contactor modelling effort were erroneous. Efforts are under way to correlate the data for use in an improved model.

A new plenum housing for the experimental four-stage centrifugal contactor shows promise in permitting continued operation after failure of any one stage. Tests are continuing to refine the concept for improved performance.

The December 1986 milestone campaign to demonstrate 5.5-cm-diam centrifugal contactors in a full solvent extraction cycle with uranium under feedback control was successfully completed. The 100-h continuous campaign was performed without operator intervention. The control system responded quickly to scheduled changes in feed flow rate and composition.

The Westinghouse Idaho Nuclear Company (WINCO) contactors were received and hydraulically tested. Test results were in excellent agreement with previous experience with experimental units.

1.2 REMOTE SYSTEMS DEVELOPMENT

S. A. Meacham

Slitting cuts on liquid-metal-reactor- (LMR) type fuel ducts were performed with no detectable fuel cladding damage when the cuts were made tangent to a hex corner. The detailed design of a remote automated sampling system for the Power Reactor and Nuclear Fuel Development Corporation (PNC) was initiated and is progressing on schedule.

Acceptance testing on the interface package of the Advanced Integrated Maintenance System (AIMS) was performed, and a test report was issued. Testing was completed on the Manipulator Test—Test Stand (MTTS) using the Model M-2 servomanipulator system. Operator skill tests, which the operators will use in this program, were also completed at ORNL and in Japan at PNC.

1.3 STRATEGIC PLANNING AND ANALYSIS

J. G. Stradley

Significant process was made in the development of the details of a broadened joint collaboration between the DOE/CFRP and the PNC. This collaboration, when agreed upon, will include all reprocessing topics.

A Commissariat à l'Energie Atomique (CEA) Technical Specialists' meeting was held at ORNL in October 1986 to plan for the implementation of a joint program to demonstrate an environmentally hardened remote control system to use with advanced manipulator maintenance systems.

2 Chemical Process Development

W. S. GROENIER

The Chemical Process Development Section is responsible for the development of improved chemical processes and components for nuclear fuel reprocessing, in particular, and also for other portions of the nuclear fuel cycle. This is accomplished through concept identification, development from laboratory-scale through full-size engineering prototypes, and demonstration in the IPD portion of the Integrated Equipment Test (IET) facility. The IPD provides a capability for conducting chemical processing demonstrations that are prototypical of a pilot-scale operation. The primary objectives for FY 1987 are to (1) demonstrate a complete uranium cycle of solvent extraction using advanced centrifugal contactors under feedback control; (2) demonstrate automated operation and process control of a centrifugal contactor solvent extraction system with related process-handling equipment; (3) prepare a series of reports that summarize the status of technology for chemical fuel reprocessing systems and components; (4) continue advanced development of centrifugal contactor rotors and housings emphasizing drive protection components, enhanced reliability, and difficult mass transfer systems; and (5) complete fabrication and testing of centrifugal contactors for evaluation in other DOE facilities.

2.1 PLANNING FUNCTIONS

J. H. Shaffer

The planning activity for the Chemical Process Development Section provides coordination of proposed engineering development activities from the various R&D groups within the CFRP for demonstration within the IPD facility. Proposals for demonstration tests are defined by formal test plans that are reviewed and scheduled for subsequent pilot-plant operations. These are performed according to specific test instructions. Sustained operations (campaigns) may involve the simultaneous operation of several related experimental efforts.

During this period, coordination was supplied for the demonstration tests of a fluidic pump, the centrifugal contactors, and the uranium product evaporator as reported in Sects. 2.2.2, 2.4.2, and 2.5.1 of this report.

2.2 FEED PREPARATION SYSTEMS DEVELOPMENT

B. E. Lewis

2.2.1 Dissolution

B. E. Lewis, O. O. Yarbro, and J. F. Birdwell

Studies and development activities on continuous dissolution will be summarized in a special report that will document the rationale for a continuous dissolver. The IET facility rotary dissolver will be maintained for use in tests as necessary.

A test plan for determining the feasibility of operating the IET continuous rotary dissolver without steam addition was revised and reissued. Operation without steam addition would result in the elimination of the in-cell steam generator dedicated for use on the dissolver system and would minimize product dilution. Enthalpy balance calculations around the dissolver are currently being performed to estimate the probability that the no-steam operation will be successful. The experiments have tentatively been scheduled for the end of February 1987.

As part of the collaborative agreement with PNC, a study will be performed to assess the feasibility of a geometrically favorable, continuous dissolver that would eliminate the need for a soluble poison in the head-end process steps. The initial groundwork for this effort has established a preliminary criteria document, a work schedule, and two design proposals. Review of these proposals has resulted in several useful suggestions and pointed to some areas where additional thought is needed, such as in the housing design, remote maintenance features, hulls, handling, materials of construction, and relevance with PNC concepts. Criticality calculations are currently being made with preliminary indications that the initial designs may be conservative. Plans are being made to fabricate an operating plastic model to demonstrate the merits of the preferred concept.

2.2.2 Fluidics, Clarification

B. E. Lewis, J. G. Morgan, E. L. Nicholson, and W. D. Holland

A summary report will be prepared to assess the needs for feed clarification based on projected flowsheets and selection of processing components, summarize methods used in various facilities and their effectiveness, describe current CFRP developments, and provide a plan for a development program on a backflushable centrifuge. The variety of fluid transfer devices necessary for the operation of a reprocessing plant will be assessed and documented. This report will also describe previous CFRP studies and recommend pilot-plant fluid transfer devices. Fluidic devices that can serve as control units or function in a slave mode to enhance the effectiveness of pulsatile fluidic pumps are to be evaluated.

Insoluble material collected in the feed clarification centrifuge during the April 1986 IET campaign has been analyzed by spark-source mass spectroscopy. A sample of the U_3O_8 powder fed to the dissolver was also analyzed and found to contain 260 ppm carbon. A sample of the cake from the centrifuge was determined to contain a variety of elements, including Al, Ni, Fe, Cr, Si, organic C, and Zr. The aluminum in the sludge was attributed to the straps holding the fuel bundles together, and the zirconium was attributed to the fuel cladding. Silicon and organic carbon represented the majority of the insolubles, and these probably entered the dissolver as contaminants in the head-end process steps. Several other elements were found in varying quantities; these may have accumulated in the recycle acid and become trapped in the sludge collected in the centrifuge bowl. These elements included P, K, Zn, S, Ti, W, and Hf.

A pulsatile fluidic pump was used in the April 1986 IET campaign to routinely transfer dissolver solution to the feed clarification centrifuge. The pump is installed in a 6-in.-diam pipe thimble in the feed preparation area. A successful demonstration of the pump performance in emptying the contents of a 1500-L feed surge tank was recently made. The fluidic pump was used to completely drain the surge tank with only the liquid fallback from the discharge line remaining in the thimble located 5 ft below the floor level. The installation required the pump to transfer fluid (vertically) 16 ft through 21 ft of discharge line.

An elevated-temperature pulsatile fluidic pump test was completed in the IET. Uranyl nitrate solution was pumped to a collection tank. A steam coil in the supply tank was used to regulate the temperature of the pumped fluid. The delivery rate of the fluidic pump was determined by the change of level in the collection tank. Thermocouples were installed to monitor temperature levels up to near the boiling point of the feed solution. A known resistance was periodically imposed in the fluidic pump outlet line to determine its effect on delivered flow rate. The fluidic pump used in these tests is the same pump used to feed the IET centrifuge head tank. Preliminary review of the data from these tests indicates relatively little decrease in pump performance at the elevated temperatures. The system resistance of the pump installation was sufficient to prevent cavitation, which was expected to be the cause of any decrease in performance of the pump.

Testing of an air-pulsed positive displacement disk-valve pump with water has been completed. Wear tests were conducted for a total of 3,256,000 pump cycles to study the durability of the disk-valve used in the pump. It lost 0.0031 g of mass during the test program. This wear rate is so low that additional testing of this type is not warranted. Engineering and development groups at the Y-12 Plant have expressed an interest in this pump as part of their process improvement work. The Y-12 groups have been working with the manufacturer of the disk valves to provide a more corrosion-resistant valve for acid service. The manufacturer currently fabricates the valves from various types of stainless steel.

2.3 AIRBORNE WASTE MANAGEMENT

R. T. Jubin, B. E. Lewis, P. Welesko, and R. M. Counce

Plans are being made for a series of off-gas treatment runs in the IET facility. These will include operation of the Iodox tower, the acid concentration system, the dual dissolver condensers, and both NO_x recovery systems. It is expected that three runs will be scheduled and completed between July and September of 1987.

A special report is to be prepared for PNC that will summarize the U.S. development status on off-gas treatment processes to include the Iodox and silver zeolite processes for iodine retention and the selective absorption process for krypton retention. The report will also provide results of attempts to regenerate solid sorbents, assess the applicability of the work for reprocessing plant applications, and present the overall U.S. philosophy for off-gas treatment.

2.4 SOLVENT EXTRACTION SYSTEMS DEVELOPMENT

R. T. Jubin

2.4.1 Centrifugal Contactor Development

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

The contactor design basis will be refined with respect to basic internal parameters such as weir size, rotor bottom taper, and shape of the cavity below the rotor. Uranium mass transfer efficiencies will be determined throughout the hydraulic operating envelope using experimental and prototype contactors. The overall design basis for solvent extraction contactors (of any type) will be summarized in a special report to PNC. The report will address requirements for mixing, residence time, and phase separation. The WRALPH code for contactor design will be updated by including algorithms that account for contactor design variables not previously considered such as aqueous vane length and rotor bottom taper.

A new plastic single-stage housing is being designed that will include provisions for withdrawing samples of the solution from the annular region, for determining the pressure at various positions within the annular region, and for allowing the replacement of the lower portion of the housing itself to permit testing of various housing configurations. Special vanes will be installed in the lower portion of the housing in an attempt to maintain more consistent liquid levels in the annular region. This is important for units with overflow ports, where at high throughputs liquid rises to these ports, or where at low throughputs, virtually no liquid is in the mixing zone.

Fabrication of new rotor and housing bottom components has begun. These components will be used with the modular 5.5-cm-diam rotor in an effort to improve mixing at the lower flow rates and extend the low flow rate end of the operating envelope.

Efforts to characterize performance in the couette region of the centrifugal contactor have continued. Current work is focused on (1) the development of estimation techniques for the height of the fluid in the couette region as a function of the operating parameters and (2) the development of a technique to verify the couette height for operating contactors.

Tests have been performed to measure the couette region and rotor holdup volumes and consequent solution residence times. Test data have indicated that the phase ratios in the couette and rotor are often much different than the flow ratio based on feed streams.

This is of particular interest because the computer code that models the contactor hydraulic behavior assumes the phase ratio in the couette and rotor to be identical to that of the feed streams. The residence time for each phase can be determined by dividing the holdup volume by the respective flow rate. Efforts are under way to correlate these data for predictive purposes.

The long-range test goal is to use the direct volume measurement to characterize the couette holdup volume and consequent mean residence time for both the continuous and dispersed phases. The couette holdup volume will then be fitted to an empirical relationship based upon a dimensional analysis technique reported in the literature for mixed tanks.

Two flowsheets have been developed for the February and April 1987 IPD campaigns. The first flowsheet has been designed to permit high uranium losses so that mass transfer efficiencies can be determined. Because it is also desired to investigate zirconium mass transfer, the second flowsheet was designed to minimize uranium losses while providing for satisfactory scrubbing of zirconium. Each flowsheet will be used with a 14- and an 18-stage cascade of contactors. The 14-stage cascade will be used during the February campaign, and the 18-stage cascade during the April campaign.

Testing has continued on the new plenum housing for the experimental four-stage contactor. This housing is designed to permit continued operation after failure of a single stage. The initial tests showed good phase separation around the stopped (dead) stage by the weirs installed in the plenum for the two internal stages. This means that the adjacent stages do not have to handle the increased liquid burden as with the original horizontal overflow port design. However, the total throughput of the unit was less than with the previous design, a condition resulting from improper weir placement. After various modifications, including modifications to the upper housing discharge ports to minimize dispersion formation in the dead stage, preliminary tests showed that when the aqueous discharge stage fails, the flows of the two phases are now correctly directed with less than 1.5% cross-phase contamination of organic in the aqueous product. Testing remains to be completed on the organic discharge stage and to optimize the internal weir heights and designs.

2.4.2 IPD Solvent Extraction

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

Development of improved methods for protecting the contactor drive units from process solutions is continuing. The contactor test stand has been operated in a 100-h campaign with a uranium flowsheet using prototype 5.5-cm-diam contactors. New contactor drive units now on order will be evaluated with respect to performance, cost, and integration with drive protection components.

An operating campaign with the 5.5-cm-diam contactors and all associated support systems was conducted in November 1986. The contactors were operated at or near the proposed Breeder Reprocessing Engineering Test (BRET) facility flowsheet conditions. The purpose of this campaign was to evaluate system operation ("shakedown"). During the campaign several problems involving air entrainment in various streams external to the contactors were experienced. Entrainment was especially pronounced in the liquid lines to the photometers on the HA and HC contactor banks. These problems were alleviated temporarily by the installation of deentrainment pots and small metering pumps in the lines to the photometers.

Of special concern during the run was the finding that the photometer windows, particularly on the HA photometer, become "dirty" rather quickly, resulting in inconsistent readings. The readings varied by ±30% on a recycled homogeneous solution. This is not a new problem, and a long-term solution will be sought. Simple cleaning with a nitric acid solution does little to correct the situation, but based on one test, methanol provides significant relief for a few hours. The problem will be examined in more detail during the next few months, and a workable cleaning and/or filtration system will be recommended for installation in the IPD.

A major milestone campaign with the 5.5-cm-diam centrifugal contactors was completed in December. This run demonstrated full-cycle uranium operation under feedback control. The tests used depleted uranium in feed solutions of 225 to 275 gU/L. The run showed that the feedback control loops (photometer-based) could adjust the process flow rates to maintain the proper uranium concentration profile in the system and that the specified quantity of uranium could be processed for a test period of at least 100 h without operator interaction. The PC-based data logging equipment was shown to monitor the system and take the proper corrective action to major equipment problems. The entire system worked very well, and the run was highly successful. No controller perturbations were observed during steady-state operation. In addition, the control system responded quickly to scheduled changes in the feed flow rate and composition. The photometers did, however, show the same behavior as noted in the November run, but the scatter in output values was not serious enough to pose a significant problem over the 100 h of the run.

The two prototype, intrinsically balanced 5.5-cm-diam rotors were tested for vibration to determine if the design and fabrication methods used produced rotors that were intrinsically balanced. A Dayton 24-v dc drive unit was used for the vibration testing and was individually established to have a vibration velocity of 0.1 in./s when operated at ~4000 rpm. The four-part rotor was connected to the Dayton drive and operated at the same speed resulting in a maximum combined vibration velocity of 0.15 in./s. The same conditions were utilized for the six-part rotor test, resulting in a combined vibration velocity of 0.19 in./s. This operating level is considered in the smooth range, and rotor balancing was not required.

2.5 CHEMICAL PILOT PLANT

D. R. Moser

The IPD portion of the IET facility is a versatile engineering laboratory that permits the test and operation of chemical processes and equipment that are prototypical of those intended for deployment in an advanced fuel reprocessing facility

2.5.1 IPD Process Operations

P. Welesko, B. B. Spencer, and J. F. Birdwell

This activity provides for the overall operations of the IPD portion of the IET facility, including equipment installation; systems and equipment checkout and startup; the performance of tests; and overall facility maintenance.

Installation of the 5.5-cm-diam centrifugal contactor test stand and supporting equipment was completed. Checkout of the individual components proved successful. A preliminary run to integrate the test stand with the supporting systems provided one week of continuous operation to (1) make necessary equipment modifications as problems arose; (2) provide a preliminary evaluation of the process flowsheet; (3) determine tuning parameters for the photometer control loops; and (4) provide the operators practice with startup, shutdown, and overall system operation. Subsequent continuous operation of a full solvent extraction cycle with uranium under feedback control was successfully demonstrated for a period of 100 h.

To provide data in support of the continuing automation effort, a test of the uranium product evaporator was completed. Process samples were obtained after attaining steady-state operation at various test conditions. Sample analysis data, along with tank instrumentation data, will be used to establish correlation coefficients for evaporator performance.

A high-temperature fluidic pump test was completed. Using various pump motivation pressures, solution temperatures, and exit valve positions, 22 separate tests were performed. The pump performed well at all conditions.

Work has continued on the modifications and improvements to extend the operating range of the environmental test chamber (ETC) to the design limits. An additional effort was initiated to improve the performance of the gas analyzers. An assessment of the problem indicated that the samples must be delivered to the analyzers at more controlled pressures. The existing piping arrangement of the sampling loop can be adjusted to operate satisfactorily with the humidity and oxygen analyzers, but the NO/NO_x analyzer requires a pressure greater than the existing equipment can reliably accommodate. A booster pump has been purchased to correct this problem.

The ETC is equipped with open trays into which nitric acid solution can be pumped. Acid spills of various sizes can be simulated by filling as many trays as are appropriate. Evaporation of the acid constitutes the process by which the cell atmosphere is contaminated. Although satisfactory for the simulation of spills, this method is not suitable for introducing acid vapor in an experiment where the rate of input must be precisely known. A metering pump has been purchased which will deliver acid solution at precise rates to a steam-heated open container where the acid will evaporate on contact.

The fabrication deficiencies in the air-handling unit will be corrected by the contractor according to a recently negotiated agreement. The contractor will provide replacement heat exchange coils of the correct type. The agreement allows other modifications to proceed as necessary with no further interruption in the planned activities.

2.5.2 IPD Process Controls

J. E. Dunn, B. B. Spencer, J. C. Suddath, and O. O. Yarbro

Studies that develop and promote advanced process control concepts are being continued with emphasis on automatic control of the contactor test stand. Maintenance of the IPD instrumentation and control systems is also included in this activity.

The process operation diagrams, software implementation diagrams, and software development and debugging of modules 1907 and 0923 (the uranium product and feed accountability system automation programs) were completed. Both modules are scheduled to be tested with hardware systems in January 1987.

2.6 LABORATORY STUDIES

J. T. Bell, D. O. Campbell, H. A. Friedman, and L. M. Toth

Summary reports are being prepared that document U.S. flowsheet chemistry activities of the past several years. Areas to be included are solvent treatment, plutonium partitioning chemistry, kinetics factors in Purex, and fission product chemistry. The status of research efforts will be described, and methods for continued collaboration will be outlined.

New distribution data are to be measured for U, Pu, and HNO_3 in low-temperature, low-tributyl phosphate content systems for use in computer simulations of the modified Purex process. Data for low-temperature redox and disproportionation of Pu(IV) will also be measured.

The study of the Pu(IV) disproportionation reaction,

$$3\ Pu^{4+} + 2\ H_2O = 2\ Pu^{3+} + PuO_2{}^{2+} + 4\ H^+\ ,$$

has continued in an effort to determine equilibrium quotients and kinetics at temperatures from 5 to 25°C both with and without uranyl nitrate present. Preliminary results show that solutions containing uranyl nitrate equilibrate much faster than those without uranyl nitrate and that equilibrium concentrations of products are less at higher acidities, lower temperatures, and/or with uranyl nitrate present.

2.7 ANALYTICAL CHEMISTRY DEVELOPMENT

D. A. Costanzo, L. N. Klatt, and J. M. Keller

Special summary reports will be prepared that document the status of U.S. activities for analyzing high-gamma samples (with emphasis on uranium and plutonium analyses) and in-line instrumentation development.

The development of X-ray fluorescence as an analytical technique applicable to fuel reprocessing has continued. An apparatus to support and align the X-ray tube and an optical bench with horizontal and vertical position control were designed and fabricated. A lead-lined containment box was also provided for the sample and X-ray tube. 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 using an old X-ray tube indicate an improvement in sensitivity and resolution with this system. Spectra obtained with the initial proof-of-principle system displayed one of the strontium K-alpha X-ray energy levels as a shoulder on the other K-alpha level; however, these two energy levels were resolved with the new high-resolution detector. The improvement in sensitivity was expected from operation of the X-ray tube at constant potential relative to full-wave rectified potential. A new X-ray tube will be installed, and evaluation of the system will continue.

Several candidate materials 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. Vitreous carbon, also known as glassy carbon, best meets the necessary requirements for a suitable cell window. About 51% of uranium L radiation was observed with a 2-mm-thick vitreous carbon window in front of a sample positioned with 45° incident and take-off angles. The percentage compares well to the predicted result of 56.5%. Similar results were observed for strontium K radiation (a surrogate for plutonium L radiation), with 54% experimental versus 58.7% calculated. Predicted results indicate a loss of <25% for a 1-mm-thick window.

2.8 ION SPECIMEN MONITORING

E. D. McClanahan
Battelle-Pacific Northwest Laboratories (PNL)

Krypton-implanted specimens prepared at PNL in FY 1985 will be monitored for releases, and the results will be documented.

2.9 OTHER ACTIVITIES

2.9.1 WINCO Contactors

R. T. Jubin

Laboratory and prototypic centrifugal contactor units are being fabricated for proof testing at ORNL and shipment to WINCO.

The fabrication of the four-stage stainless steel and single-stage plastic WINCO contactors has been completed. Hydraulic testing of the units showed excellent agreement with tests of the plastic development model. In fact, the WINCO four-pack exhibited slightly better performance than the original plastic unit. The entire testing phase was uneventful in that the units performed flawlessly upon receipt from the vendor.

2.9.2 Y-12 Contactors

R. T. Jubin and J. F. Birdwell

Laboratory and prototypic centrifugal contactor units are being designed for the Y-12 Plant. Upon fabrication, they will be proof-tested at ORNL.

3 Remote Systems Development

S. A. MEACHAM

The Remote Systems Development Section is responsible for the design, procurement, and testing of equipment and systems for process cell applications. Major efforts are directed to the development and evaluation of teleoperated maintenance systems, mechanical head-end equipment, and robotic devices for automated sampling of process fluids. Activities for this section are concentrated in two functional groups: the hardware development group and the technology development group.

3.1 HARDWARE DEVELOPMENT

J. H. Evans

The activities and responsibilities of this group include the development of an in-cell sampling system and equipment that are required for the mechanical preparation of nuclear fuel for downstream processing. The sampling system consists primarily of a track-guided robotic vehicle, sampling stations, and an out-of-cell control system. Equipment required for the mechanical preparation of the fuel includes a laser disassembly system, a shear system, and an overall control system. Summary descriptions of this equipment and current activities are provided in the following sections.

3.1.1 Remote Automated Sampling System

J. H. Evans, R. M. Mouring, and K. N. Castleberry

The remote sampler is an automated, in-cell sampling system that can collect samples of process fluids from various points within a radiochemical system and transport them to a central location for subsequent transmittal to analytical cells. This system will be designed, fabricated, and tested by ORNL and provided to PNC for installation in a coldtest facility. The equipment being developed for PNC is very similar to a robotic sampling system that has been successfully operated for the past several years at ORNL in the Remote Operations and Maintenance Demonstration (ROMD) facility.

Detailed design of the system is currently under way. The track, sample stations, and support structure drawings are now in checking. The preparation of vehicle details has been initiated, and definition of the control system is in progress.

3.1.2 Mechanical Head-End (Disassembly and Cutting)

J. H. Evans, C. F. Metz, W. F. Johnson, E. C. Bradley, and D. J. Richards

The mechanical head-end consists of 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 been installed in the ROMD area of Building 7603.

During this period, development activities to establish laser cutting techniques and parameters continued with emphasis on slit cutting on LMR-type fuel. Numerous test cuts demonstrated that the design basis of cutting along the hex flat would result in significant damage to the fuel. However, test cutting tangent to the hex corner resulted in no detectable fuel damage. A design study has been initiated to determine the magnitude of effort required to modify the disassembly system for this type cutting.

The preparation of a summary report on shearing of prototype fuel is about half complete in draft form.

3.2 TECHNOLOGY DEVELOPMENT

S. L. Schrock

The efforts of this group are directed towards the development of improved remote maintenance systems for application in hazardous environments. The activities include equipment development and testing and evaluation of man-machine interfaces and operator efficiencies. These activities are further described in the following sections.

3.2.1 AIMS

J. C. Rowe, D. P. Kuban, E. C. Bradley, C. T. Kring, M. W. Noakes, S. D. Zimmerman, and P. E. Arakawa

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 use for future demonstrations for remote handling applications. Key features to be demonstrated in the AIMS include: (1) modular remote maintainability of manipulator slave arms, (2) improved operational flexibility through modern digital control techniques, (3) servo-control of overhead transporter systems, (4) wireless signal-transmission techniques for reduced cable handling, (5) radiation-resistant electronics, and (6) improved operator efficiency through flexible man/machine interfaces.

Software development, system tuning, acceptance and performance testing, operator training, and system demonstrations were the main activities for the AIMS during this quarter. A full calibration of the Advanced Servomanipulator (ASM) slave system was completed. Retuning of the arms for all force-reflection ratios was also completed.

Acceptance testing was performed on the interface package system, and a test report was issued. This system serves as the interface for attaching the slave arms to an overhead transporter to provide cell mobility and represents the balance of the in-cell remote maintenance equipment. This system includes an azimuth drive, three cameras mounted on positioners, and an extendable auxiliary hoist.

Performance testing on the ASM master/slave system was initiated during this quarter. The objective of this testing is to compare the performance of the ASM to the design requirements. Early tests indicated less than satisfactory performance on force capacity and force-reflection sensitivity. Some improvement in performance was observed when the arms were retuned; however, further software corrections appear to be necessary.

Development of software for the Operator Control Station continued during this period. A new Local Area Control Network was completed. This network ties together the separate out-of-cell computer racks into a fully integrated and unified system so that each computer can communicate with all other network computers in a real-time control mode. The fabrication and checkout of a pendant controller, consisting of the transporter, cameras, crane, and interface package hardware, were also successfully completed.

Efforts were also directed towards the development of a microwave system for wireless signal transmission in AIMS. A single-channel system was successfully operated during this period, and a multichannel system, to be installed and demonstrated on AIMS, is currently being prepared. In addition, a technical report summarizing ORNL experience with various signal transmission techniques is being prepared for submittal to PNC as part of a collaborative program with Japan.

Work has been initiated to develop the fixturing required to demonstrate the remote maintainability of the ASM slave arms. This effort will utilize the M-2 servomanipulators in the ROMD facility to perform the remote maintenance demonstration. A preferred approach for this effort has been determined, and the necessary fixturing is currently being designed.

Efforts are also continuing to transfer the ASM technology to industry via a commercialization activity. Discussions are being held with companies that have expressed an interest in participating in this effort.

A program was also initiated during this period to develop radiation-hardened electronic systems. This activity is a collaborative effort with the French CEA, and the components that are developed will be tested in the AIMS facility at ORNL and in the TOR facility in France. A program plan has been developed and is currently being circulated for approval.

3.2.2 Testing Activities

T. W. Burgess and J. V. Draper

Tests during this period were performed on the MTTS. This program is a collaborative effort with PNC in which identical tests will be performed in each country using identical test stands. Tools, test instructions, and equipment items used in the test are also identical. To compensate for differences in the capabilities of the operators, a skill test has been devised and will be administered to all the operators used in this program. In Japan, the tests, which consist of a series of discrete tasks, will be performed with Prototype II and III servomanipulator systems. At ORNL, the Model M-2 and the ASM systems will be used. The tests are designed to identify both good and bad features of the various manipulator systems and will serve as a basis for optimizing the performance of the maintenance systems.

During this period, the skill test was administered to all four of the ORNL operators, and the test program on the MTTS was completed using the M-2 servomanipulator. During the next quarter, the identical test program will be performed using the ASM. Testing by PNC is running one to two months behind the U.S. schedule although PNC did complete the skill tests on the operators that will be used on its manipulator systems.

4 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.

4.1 FOREIGN EXCHANGE AGREEMENTS

The CFRP has active agreements with PNC of Japan, CEA of France, and the United Kingdom Atomic Energy Authority (UKAEA).

4.1.1 U.S./PNC Exchange

In the Remote Systems Technology area of the exchange (Sects. 3.2 and 3.2.2), testing was initiated on the CFRP portion of the manipulator test-test stand program. An identical stand has been built in each country to use in establishing the performance of various manipulators. The ORNL tests are expected to be completed in January 1987.

In the Joint Criticality Data Development area, the PNL Critical Mass Laboratory continued to undergo physical upgrades which prevented any experiments from being conducted. Operation is expected to resume in the spring of 1987.

Significant progress was made in the development of the details of a broadened joint collaboration between the DOE/ORNL and the PNC. This collaboration, when agreed upon, will include all reprocessing topics. It is envisioned that the first year will focus on jointly developing an understanding of the status of the R&D in several major reprocessing areas and then accomplishing detailed planning for future work.

An activity is under way examining ways to configure reprocessing equipment racks which will reduce cell space without compromising the operational or maintenance capabilities.

4.1.2. U.S./French CEA Exchange

This exchange focuses on the area of Remote Systems Technology. A technical specialists' meeting, held in the United States in October 1986, focused on the planning for the implementation of a joint program involving the demonstration of an environmentally hardened remote control system for use with advanced manipulator maintenance systems.

4.1.3 U.S./United Kingdom Atomic Energy Authority (UKAEA) Exchange

At the November 1986 meeting of the ad hoc Fuel Cycle Steering Committee, some new potential exchange topics were discussed.

Testing continued on the U.S. fibre-optic spectrophotometry equipment which has been installed in the UKAEA Dounreay Fast Reactor Reprocessing Plant.

A final report prepared by ORNL describing the results of the ORNL test on a UKAEA centrifugal clarifier was completed.

4.2 SAFEGUARDS ASSESSMENTS

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 for monitoring plant operations. Details are being developed for 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
ETC	Environmental Test Chamber
FRD	Fuel Recycle Division
IET	Integrated Equipment Test
IPD	Integrated Process Development
MTTS	Manipulator Test—Test Stand
ORNL	Oak Ridge National Laboratory
PFR	Prototype Fast Reactor
PNC	Power Reactor and Nuclear Fuel Development Corporation
PNL	Battelle-Pacific Northwest Laboratory
ROMD	Remote Operation and Maintenance Demonstration
UKAEA	United Kingdom Atomic Energy Authority
WINCO	Westinghouse Idaho Nuclear Company

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