MASTER

**CORE RESTRAINT DEVELOPMENT
QUARTERLY PROGRESS REPORT
FOR PERIOD ENDING
AUGUST 31, 1975**

APPLIED TECHNOLOGY

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Westinghouse Advanced Reactors Division

Prepared for the U. S. Energy Research and Development Administration Division of Reactor Research and Development Under Contract No. E(11-1)3045

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August 31, 1975

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1.0 INTRODUCTION AND SUMMARY

1.1 GENERAL

This quarterly progress report covers work performed between June 1, 1975 and August 31, 1975.

1.2 SUMMARY OF OBJECTIVES

The liquid metal fast breeder reactor (LMFBR) requires a core restraint system to provide both axial and radial support for the reactor assemblies. The primary requirements of the core restraint system are: (1) fuel, control blanket, and removable shield assemblies must be located in predictable and reproducible positions; (2) refueling should be accomplished without damage to the assemblies; and (3) operating loads must not be excessive. Variables affecting the core restraint system are primarily the radiation-induced materials effects of swelling creep and load pad friction characteristics. These cause bowing deformations of the core assemblies during life. The objective of this development program is to evaluate potential restraint concepts both analytically and empirically. A test facility will be prepared with the capability of modeling axial and radial core support and restraint systems of various LMFBR designs. Simulated core assemblies will be designed and fabricated. Attendant analyses will indicate important structural parameters to be considered in fabrication and subsequent testing. Development of three-dimensional analytical models will be continued for detailed performance studies of particular core restraint systems.

1.3 SUMMARY OF PRIOR WORK

Near-term activities of the national program are directed toward the specific needs of the Clinch River Breeder Reactor Plant (CRBRP) core restraint design and development effort. Beginning in Fiscal Year 1972, considerable effort has been directed toward these activities. A comparative performance study was issued in 1972. This effort was based on concepts with which design and/or analysis was available. Following this study, the core restraint concept was selected for the CRBRP. Construction of the full-scale three-dimensional core restraint facility was initiated in 1972. At that time, compaction tests on the 199-assembly mockup of the FTR core were nearing completion at HEDL. Planar Core Mockup (PCM) tests had been initiated under the direction of GE. Both of these efforts marked the beginning of an established data base for detailed analysis of LMFBR core restraint systems. PCM tests initiated the evaluation of specific bridging properties under planar loading conditions. A significant product of the PCM tests and subsequent development work at GE was the technology necessary to accurately measure interfacial loads between test core assembly load pads. In early Fiscal Year 1974, the National Core Restraint Program Plan was issued by Westinghouse. This document identified key elements of the national plan necessary to develop a satisfactory core restraint system for the LMFBR program. This program plan, issued in preliminary form one year earlier,

had been updated to reflect the requirements of the CRBRP project. One of the main objectives of the national program was the development of analytical tools for core restraint structural analysis. In 1973, ANL and Westinghouse reviewed existing structural analysis codes in an effort to select one to be used to develop a special core restraint code. As prescribed by the program plan, both three-dimensional inelastic (NUBOW 3-D) and semi-empirical (PARABOW) computer code development efforts were initiated in Fiscal Year 1973.

In Fiscal Year 1974, a specification for a Core Restraint Thermal Hydraulic Transient Code (CORTAC) was prepared by GE. ANL is developing a two-dimensional version of this code. The construction of the three-dimensional test facility has been completed. A technique to accurately measure duct assembly position and elastic bow under test was developed by Westinghouse. This capability, combined with the "adjustable above core load pad" feature used on three-dimensional simulated fuel assemblies, has resulted in a highly flexible test bed for detailed core restraint development testing. Instrumented assemblies provided by GE to measure interfacial loads are currently in use to provide discrete load data for bridging studies.

The initial 121-assembly tests at ARD are complete. Data were transmitted to LMFBR contractors on a regular basis for use in specifying CRBRP design criteria and calibration of structural codes under development. PARABOW, NUBOW 3-D (inelastic), and CORTAC development and calibration effort at ANL are nearing completion. PARABOW is now being run at Westinghouse. Plans are being made for full-core tests scheduled for the winter of 1975 at Westinghouse. Hardware for simulated fuel assemblies and facility modification is being designed and placed on order. Eight additional instrumented assemblies will be provided by GE for full-core tests.

Plans have been completed to study effects on straight assembly cores for the 121 assembly configuration. The modeling techniques used by ANL in PARABOW may be incorporated in codes used by ARD. Withdrawal force tests on single assemblies being carried out at HEDL were completed.

A study was completed to investigate the best method to simulate an insertion/withdrawal assembly. The use of a hex duct assembly array was the primary object of this study. These insertion/withdrawal assemblies will be used in full core testing. In February, ARD provided a recommendation for the National Core Restraint Development Program. Approximately 25 percent of all components used for the simulated blanket assembly (SBA) were delivered. Partial shipments of components for the insertion/withdrawal fixture were delivered. Assembly of the fixture is about 15 percent complete.

1.4 SUMMARY OF CURRENT WORK

Upon completion of Phase V of testing, extensive checks of the facility

alignment took place. SFA's were realigned for the 121-assembly straight core test. A special test was performed to check the jaw loading characteristics after facility alignment. Much of this testing was delayed due to (1) installation of an overhead crane; (2) installation and checkout of the new multiplexer system. About 54 percent of the components for the simulated blanket assembly have arrived. All necessary components for the insertion/withdrawal fixture have arrived. Approximately 40 percent of the assembly is complete. An engineering study report is being written to describe the best method to implement full core insertion/withdrawal tests. Phase VI of testing (straight core) is scheduled to begin in early September.

Withdrawal force tests on single assemblies by GE/FBRD at HEDL were completed and the final report has been issued. It was learned that GE/FBRD would not fund the frictional tests of ARD test components at HEDL due to budgetary adjustments. A study has been initiated to develop an alternate testing method to obtain this experimental friction test data.

2.0 PROJECT ADMINISTRATION

2.1 OBJECTIVES

The objectives of this task are to assure that the project is successfully completed, on schedule, within budget, and to the satisfaction of the Energy Research and Development Administration (ERDA); to assure compliance with contractual obligations; and to coordinate this project with other ERDA-sponsored and Westinghouse-sponsored LMFBR development projects.

Overall project direction and day-to-day administrations will be provided under this task. Plans and control will be established and maintained; periodic reviews will be held with ERDA; correspondence and reports will be coordinated; and day-to-day technical and administrative liaison with ERDA will be provided.

2.2 PRIOR WORK

The project schedule was updated monthly to reflect the progress attained during each month. Work related to the present investigation and performed prior to this period has been reported in the following reports:

WARD-3045T2B-1	Core Restraint Development First Quarterly Progress Report for Period Ending February 29, 1972.
WARD-3045T2B-3	Core Restraint Development Second Quarterly Progress Report for Period Ending May 31, 1972.
WARD-3045T2B-4	Comparative Performance of Three Candidate LMFBR Core Restraint Systems Considering Uncertainties in Irradiated Materials Effects, October 1972.
WARD-3045T2B-5	Core Restraint Development Quarterly Progress Report for Period Ending August 31, 1972.
WARD-3045T2B-7	Core Restraint Development Quarterly Progress Report for Period Ending November 31, 1972.
WARD-CR-3045-1	Core Restraint Development Quarterly Progress Report for Period Ending May 31, 1973.
WARD-295	National Core Restraint Development Program, July 1973.
WARD-CR-3045-3	Core Restraint Development Quarterly Progress Report for Period Ending August 31, 1973.

WARD-CR-3045-4	Core Restraint Development Quarterly Progress Report for Period Ending November 30, 1973.
WARD-CR-3045-5	Core Restraint Development Quarterly Progress Report for Period Ending February 28, 1974.
WARD-CR-3045-6	Core Restraint Development Quarterly Progress Report for Period Ending May 31, 1974.
WARD-CR-3045-7	Core Restraint Development Quarterly Progress Report for Period Ending November 30, 1974.
WARD-CA-75-074	Recommendation for Core Restraint Development Activity Work Scope for the Period Fiscal Year 1975 Through Fiscal Year 1979.
WARD-CR-3045-8	Core Restraint Development Quarterly Progress Report for Period Ending February 28, 1975.
WARD-CR-3045-9	Core Restraint Development Quarterly Progress Report for Period Ending May 31, 1975.

2.3 CURRENT PROGRESS

The schedule for this task has been updated monthly to reflect work accomplished during the month, and the effect of current progress upon task milestones has been evaluated.

3.0 TECHNICAL PROGRESS

3.1 SUMMARY OF OBJECTIVES

The objective of the National Core Restraint Program is to provide the analytical tools necessary for core restraint analysis of large core arrays. Three-dimensional effects of ducts loaded under simulated operating conditions are to be experimentally evaluated. This evaluation will provide the data necessary for development of modeling techniques and specialized core restraint analytical codes. Loading conditions to be evaluated experimentally include studies of both operating and refueling conditions. Special load transmissibility studies will also be carried out to identify effective modes of duct loading under lateral seismic accelerations. Specific tasks necessary to satisfy this objective are as follows:

- Systematically evaluate the core restraint concepts against reactor system requirements.
- Develop the analytical methods required to evaluate the concept and components.
- Perform the necessary tests to aid in the selection and verification of analytical techniques.
- Verify that the selected concept meets the requirements of the LMFBR core restraint system.
- Monitor and transmit requirements to LMFBR technology programs to obtain design data to be used in analysis.

Core restraint system design is dominated by the need to accommodate the effects of fast flux irradiation on core structural materials. Irradiation-induced swelling and creep can produce permanent bowing, transverse swelling, and dilation of the core assembly flow ducts. This problem of predicting the mechanical and structural response of the core to both thermal and mechanical loading is of particular concern to the core restraint system designer. The core restraint system must be selected so as to minimize the adverse effects of swelling and creep on core performance. Specifically, it must be shown that core former and interassembly gaps are sufficient to provide for satisfactory insertion/withdrawal loads and are suitable for reactivity insertion margins without compromising core assembly duct integrity. Due to the complexity of the structural core restraint model and the effects of three-dimensional loading, analyses of systems of this type are complex. Nonuniform gap distribution within the system is such that individual ducts may act either as individual mechanisms or as elements of an elastically coupled system.

3.2 PRIOR WORK

The test rig structural steel, core plates, and lateral loading system drives were assembled and aligned during the second quarter of 1973. The floor surrounding the test area was paved and sealed. The structural steel, core plates, and access decking were then painted. Control panel modules were assembled, and first generation instrumentation and controls were installed. Wireways for instrumentation and control circuits were fabricated, and the motor control circuits for the twelve lateral loading systems were completed. Lateral jaw actuator assemblies were installed and aligned. Mechanisms for jaw movement were tested and prepared for test. Core plate friction bushings to simulate inlet nozzle friction characteristics were installed. The method for alignment of the core restraint facility was documented and issued.

The design for the simulated fuel assembly to perform core restraint development tests for the demonstration plant was established and necessary hardware was procured. A detailed analysis of the load pad to be used on the simulated fuel assembly was performed. Friction testing of coupled materials led to material selection for load pads: flame sprayed nickel-chrome alloy and inlet nozzles with steel on aluminum. Load pads were designed and fabricated. A fixture for alignment of the simulated fuel assemblies was designed and installed.

An alternate approach to provide three-dimensional core restraint analysis was developed and incorporated into the program plan. This system utilized a semi-empirical analytical technique for overall system studies and specialized three-dimensional codes for localized studies. An effort to develop this capability was initiated at ANL. Design of a system for measuring simulated fuel assembly bow during compaction tests was completed. Equipment was procured, calibrated, and installed.

All electrical measuring instruments were calibrated, functionally tested, and prepared for characterization testing. The signal conditioning electronics for the instrumented simulated fuel assembly (ISFA) units and the cabling for this system were installed. Installation and checkout of the simulated fuel assembly alignment fixture was completed.

The hardware for simulated fuel assemblies was delivered and assembly was initiated. The GE instrumented fuel assemblies were received and inspected. An alternate optical alignment target to be used in the duct bow measurement assemblies (DBMA) was designed as a cost reduction effort so that additional DBMAs could be made available for test purposes.

Use of additional DBMAs reduced the time necessary for compaction tests approximately 50 percent. Design of a special fixture for insertion/withdrawal tests was completed and materials were ordered.

A revised test plan which expanded testing in critical areas was issued. The test facility was characterized before testing was started to determine

facility deflections in order to identify uncertainties in recording actual jaw position. Phases I through V of the test plan were completed. Data were reviewed and distributed to participating contractors.

A recommendation for the work scope for the National Core Restraint Development Program for the period Fiscal Year 1975 through Fiscal Year 1979 was prepared. The recommendation was issued to ERDA/RRD and to all program participants for review and comment. Hardware for an improved method for alignment of simulated fuel assemblies was made operational. Data from the instrumented assemblies for load measurement were reviewed. It was determined that these systems are functioning according to specification.

In May, 1975 a meeting with ARD, GE/FBRD, and HEDL was held to review items required by proposed DADs. Preparation of work scopes for ARD and GE was to be initiated in June. Procurement procedures to obtain load pad friction test hardware for testing at HEDL were to be initiated during June at ARD. The simulated blanket assembly (SBA) was designed and purchase orders were issued. Design of the simulated radial shield assembly (SRSA) was initiated.

Design of the instrumented load measurement assemblies (ILMA) was completed and approved. Delivery is scheduled for October 1975. Components for the insertion/withdrawal fixture were fabricated. The design of the jaw actuator system to be used for full core testing has been completed. The system has an improved lateral support system to maintain square contact of the load pad/jaw pad interface.

3.3 CURRENT PROGRESS

Sources of probable causes for facility misalignment were identified and corrected. The facility alignment procedure was revised to include the use of a new alignment tool which improves the initial radial positioning of the jaw assemblies. The SFAs and ISFAs were aligned to a "straight" condition. A special symmetry test was developed and run. The multiplexer unit (MUX) to be used in full core tests was installed. This MUX will also be used for the remainder of the 121-assembly testing.

Test hardware for proposed friction testing of load pad plates at HEDL were procured. Approximately 50 percent of the load pads are currently available for testing. Initial testing has been delayed because of funding limitations at GE/FBRD.

Final design of the necessary SFA modifications is complete. Purchase requisitions are being approved. Contracts have been placed for the fabrication of the outlet nozzle and ACLP for the full-core SFAs. Approximately 54 percent of the SBA components have been received. Purchase orders for raw materials for the SRSAs have been issued. A feasibility study for a special insertion withdrawal assembly is being continued.

Preliminary designs were completed. The addition of strain gages onto the assembly is now being considered.

Approximately 90 percent of the total components for the insertion/withdrawal fixture have been received. Approximately 40 percent of the assembly activity is complete.

3.3.1 Program Status

In February, 1975, in accordance with ERDA/RRD request, ARD provided a recommendation (WARD-CA-75-074) which stated the present and future development activity for the National Core Restraint Test Program. The recommendation, which was issued February 25, 1975, included:

- All task elements, including ANL, GE and ARD efforts.
- Funding associated with task elements.
- Identification of tasks in direct support of CRBRP.
- Identification of tasks in support of commercial LMFBR systems (1000 MW and larger).
- Identification of those long-term tasks requiring attention in the near term.

Details of this recommendation were discussed during the last reporting period. This document was prepared from inputs from ANL, GE and ARD gathered at a working meeting the same month. The purpose of the document was to identify tasks required by CRBRP and to establish long term LMFBR objectives of the program.

A working meeting with an ERDA representative was held on August 1, 1975 at ARD. The purpose of the meeting was to review the status of the National Core Restraint Program and the associated needs of the CRBRP core restraint system design effort. It was concluded that the areas needing the support of development efforts are those providing more information on frictional effects, a more definite envelope for withdrawal loads, and core load transfer properties during a seismic event. A review of current CRBRP core restraint design analytical efforts determined that increased CRBRP emphasis will be directed toward reducing modeling uncertainties due to:

- Manufacturing tolerances in hex load pad size and surface characteristics
- Duct "roll" and load pad twist in the core array

- Frictional effects
- Non-symmetrical load distribution

During a conference call with program participants on August 19, 1975, ARD suggested that the recommendation be updated to reflect the latest funding levels and the effect this has on the program participants' scope of work for FY-1976. ARD asked that a letter summarizing the participants' (GE/FBRD, ANL) suggested work scopes and funding levels be sent to ARD by mid-September 1975 for review. This data with an updated input for the recommendations will be reviewed by ARD prior to an early October 1975 meeting to cooperatively revise the recommendation.

3.3.2 Three-Dimensional Development Tests

Evaluation and proof testing of candidate or prototypical LMFBR core restraint systems requires a full-scale mechanical test facility. Facility testing complements two- and three-dimensional analytical efforts in the core restraint field and provides the capability of modeling a reactor core with a particular core restraint system. The test facility is able to model a variety of core restraint systems.

A primary objective of the core restraint testing programs is to verify the results of analytical models which are being developed to simulate the CRBRP core restraint system. These models will be used to determine the effects that a variety of operating conditions and configurations have on such parameters as fuel assembly insertion/withdrawal loads and restraint system loads. The core restraint test results will be used to "calibrate" the three-dimensional analytical models.

All phases of the initial test program (Phases I-V) are complete as defined in "Core Restraint Development 121 Assembly Compaction Test Plan, TP No. 31.4.01 - Revision No. 1." Data from these phases have been reduced, stored on punched cards, and transmitted to ANL.

A second series of Phase III tests were conducted with the core assemblies positioned 180 degrees from their original Phase III positions. These cycles were carried out to determine if loading asymmetries identified during the initial test resulted from facility misalignment or from a particular core assembly loading property. Results indicated that facility misalignment was a potential cause for the asymmetries. Therefore, a study was initiated to evaluate the symmetrical loading characteristics of the test facility. The LVDTs, load cells, and dial indicators were recalibrated according to the written procedures. Jaw targets were recalibrated and the jaws were reassembled and installed in the facility. During rig realignment, it was determined that one of the precision optical instruments used to align the jaw assemblies was not operating properly. This anomaly could have resulted in an error in absolute core dimension measurements due to incorrect radial positioning of the jaws. The facility was realigned and jaw position

was then verified with an inside micrometer. Test loadings to evaluate symmetry effects began at the end of the last reporting period.

As a result of the misalignment problem, a special calibration fixture was designed. The fixture has three surfaces which are used to locate a center target from any three non-adjacent jaws. Correct jaw radial position is achieved by moving the jaws so that the center of the fixture coincides with the centerline of the core. The fixture is calibrated to within 0.001 inch radially and reduces the uncertainty in the absolute positioning of the jaws to less than ± 0.010 inch (total accumulated) diametrically. The improvement in the accuracy of the initial jaw alignment will result in a more closely controlled peripheral envelope for the core assembly. Following calibration of the alignment fixture, studies were carried out to evaluate methods for verification of its use. The facility alignment procedure was then revised and implemented.

A test procedure to evaluate the symmetrical loading characteristics of the facility was then developed. This test series was completed late in this reporting period. Data and results will be available in the next reporting period.

The Phase VI test procedure was issued and will be run during the next reporting period. This test series is for a "straight" core configuration and includes the collection of duct bow data as well as compaction data.

During this reporting period, testing was delayed because of the installation of an overhead crane directly above the test facility. Some delay also resulted due to the installation of the new multiplexer unit (MUX) into the Data Acquisition System. The new MUX was necessary for full core testing and was installed at this time to reduce potential data uncertainties. Installation of the unit is complete and the computer programs which were written for the original MUX interface are being revised.

A method is being developed which will automatically perform calibration verifications on test facility instrumentation. The initial intention is for verification to be performed daily. This verification will reduce the number of potential retests necessary that could result due to undetected broken lead wires, poor connections, or excessive amplifier drift. This system will be implemented during the next reporting period.

A computer program was written which, for every file in a particular test phase, compared the average jaw face load with the average duct face load and determined the percentage difference between the two. This was also provided for the maximum duct face load and average jaw face load. This tabulation of loading information aids in data reduction activities.

A second program to display a core map showing interfacial loads has been written. Loads were taken from typical files in each phase and were normalized to a common jaw load. This effort provides a means to illustrate the bridging properties of various test core configurations.

3.3.3 Withdrawal Load Evaluation and Test

A series of friction tests are planned at HEDL to compliment the 3-D testing at ARD and core assembly interaction effects testing at GE/FBRD. The tests would be performed with above core load pads (ACLP) and top load pads (TLP) supplied by ARD. The combinations of test materials include:

- METCO 15E/METCO 15E
- METCO 15E/304 Stainless Steel
- METCO 15E/304 Stainless Steel/METCO 15E
- METCO 15E/Selected Low Friction Material/METCO 15E

The testing, to include both 2-face and 6-face loadings, was tentatively scheduled to begin in late summer, 1975 and be completed by January, 1976. Testing of full core components was scheduled for spring, 1976.

Prior to approval by ERDA, a detailed work scope was prepared by GE/FBRD and transmitted to HEDL. A cost estimate for this effort was then prepared by HEDL. Hardware procurement was initiated at ARD. Facility preparation was started at HEDL in anticipation of funding approval. A partial shipment of test components was received. Sufficient hardware is currently available for testing to begin.

These tests are now in jeopardy as a result of funding limitations at GE/FBRD. Budget adjustments are currently being reviewed at ERDA. Should the funding situation be favorably resolved, a test procedure would then be prepared by HEDL and submitted to ARD and GE/FBRD prior to the start of testing. HEDL is currently awaiting funding approval from GE/FBRD before resuming work.

3.3.4 Simulated Fuel Assemblies

Calibration of simulated fuel assemblies (SFA) used in core restraint loading requires a high degree of precision. Prior to assembly of each unit, individual components are manufactured and prepared for assembly. Targets for bow and position measurements are installed. Outlet and inlet nozzle components are then secured to the spine weldment and the alignment fixture is prepared. After positioning the assembly into the alignment fixture and locating the bow measurement targets on the centerline of the spine, the above core load pad (ACLP) is sealed. The serial number is then attached.

Following 121 assembly tests, the existing SFAs will be modified to simulate the CRBRP fuel assemblies for full core testing. The SFA modification consists of shortening the spine approximately 14 inches. A design has been prepared which will minimize the amount of machining necessary to perform the modification. To avoid disassembly and/or replacement of a section of the SFAs, deflection and stress analysis was utilized to aid in the final analysis. Following this effort, the high moment section will be remachined to give the SFA deflections identical to the CRBRP ducts, at several critical points. Purchase requisitions for these modifications have been prepared and are being approved.

Drawings of the full-core simulated fuel assemblies are complete. Contracts have been placed for the fabrication of the outlet nozzle and ACLP. Studies have been made of the comparison of the CRBRP blanket assembly and a simulated blanket assembly and for the removable radial shield assembly. These assemblies will be used on the full-core tests. The fuel configuration will be established when the removable radial shield design is established for the CRBRP core.

The design of the simulated blanket assembly (SBA) is complete and purchase orders have been placed. Components have begun to arrive. Approximately 50 percent of the spines have been received. The remainder will be delivered during the next reporting period. Approximately 96 percent of the ACLPs and 18 percent of the TLPs have been received.

Simulated radial shield assembly (SRSA) proposals were evaluated and a conceptual design (see Figure 1) chosen based on the current conceptual design of actual RRS assembly. Purchase orders for raw materials for the assembly, including the ACLP and the outlet nozzle, have been issued. Further design on the SRSA will be developed when a CRBRP design is prepared. The simulated assembly consists of a mechanical tube with same flexural rigidity as the actual assembly and two noncompliant load pads. The TLP will be a fixed position while the ACLP may be offset up to 0.375 inches. The drawings identify the latest reference design for the CRBRP radial shield assembly. The outlet nozzle is identical to the SFA outlet nozzle. Any changes in the CRBRP shield assembly will not effect the fabrication of the outlet nozzles.

A feasibility study is continuing on the special insertion/withdrawal assembly (Figure 2) proposed for use in the full core insertion/withdrawal tests. The objectives of these tests are: (1) establish a maximum complete withdrawal and insertion load requirement and (2) establish the relationship between withdrawal loads and jaw loading. The test data will also be used to determine pad loads for the ACLP and TLP. The special simulated fuel assembly will accurately depict the outer profile over its entire length, its flexural rigidity, and maximum tilt condition at the inlet nozzle. Two conceptual sketches were completed. One design is a carbon steel duct with solid nozzle and a bushing to simulate the inlet module. The second design is fitted with adjustable targets to allow measurement of SFA deflections during tests. The structural calculations for these designs were based on the fuel assembly design layout 766J97 and the latest inlet nozzle dimensions obtained from the CRBRP core design group.

Figure 1. Simulated Removable Radial Shield Assembly

Figure 2. Special Insertion/Withdrawal Fuel Assembly

3.3.5 Load Measurement Assemblies

Early in the conception of the Core Restraint Development Program, it was recognized that some method of measuring interfacial loads would be necessary to fully evaluate load distributions in the core. It was determined that GE would provide two such systems for the 121-assembly test program at Westinghouse ARD.

The system used is dimensionally and mechanically prototypical of the CRBRP fuel assembly. The data output is linked to the data acquisition system used for three-dimensional testing. During the course of testing, these systems are moved to different locations in the test core. This provides the information necessary to evaluate system repeatability, symmetry, and bridging networks. During Phase IV tests, the ISFAs were positioned adjacent to each other such that the adjacent faces at the Top Load Pad (TLP) and ACLP were in contact. cursory evaluation of Phase IV data has indicated that the adjacent faces at TLP and ACLP measured the same load value within eight pounds. This was true over the range of test conditions (0-500 pounds at load pad contact surfaces). This indicates the ISFAs are performing according to specification.

A Development Requirements Specification (DRS) was prepared for eight additional instrumented load measurement assemblies (ILMA) to be used with the existing systems during full core tests. The DRS was developed based on the anticipated needs of proposed core restraint tests, full core SFA design, and experience associated with the existing instrumented simulated fuel assemblies. The DRS was transmitted to GE/FBRD for delivery of the eight systems by October 1, 1975. Copies of the preliminary drawings have been submitted to Westinghouse ARD and were approved.

In accordance with the DRS, GE/FBRD informed ARD of the type of signal conditioning to be used for the ILMA's. The strain gage excitation voltage has been increased from 5V to 10V which permits the signal conditioning system to be passive rather than active. The elimination of the 96 active amplifiers provides considerable cost savings to the project.

3.3.6 Insertion/Withdrawal Fixture

Fuel assembly deformations occur due to effects of creep and swelling and thus influence the normal loads associated with insertion and withdrawal of reactor fuel assemblies. A prototypical test is necessary to evaluate duct insertion and withdrawal forces. A special fixture will be prepared for use during 121-assembly tests using simulated fuel assemblies in the core restraint test facility.

The design of the insertion/withdrawal fixture (Figure 3) has been completed. About 90 percent of the total components has been received. The insertion/withdrawal fixture assembly, alignment and checkout is in progress in an

Figure 3. Insertion/Withdrawal Test System

assembly area (prior to being positioned over the simulated core). The bridge/trolley assembly and the lifting mechanism are being assembled and leveled on a pre-fabrication test stand. Adjacent to the test stand is an instrumentation terminal panel to provide the control and power requirements. A movable control cabinet has plug-in connections between the terminal block and control panel for maintenance and calibration activity. The cabinet and controls for this system have been delivered and assembled.

The lifting beam and lead screw for the lifting mechanism have been fabricated. All necessary hardware for power supply and control equipment has been installed. A computer program has been written to determine the absolute position of a target relative to a master coordinate system. The program also identifies the correction to the theodolite base needed to obtain the exact position needed. Documentation of this information is complete.

The instrumentation system for this fixture has been designed and system components ordered. This instrumentation consists of a load cell and a position/displacement transducer. Data will be recorded on a special analog recorder and simultaneously printed on an X-Y display. The X-Y recorder will provide plots of load versus displacement. From these plots, the characteristics of insertion/withdrawal loads will be determined. The analog output will be linked to the multiplexer system and output for storage on the existing data acquisition system.

A withdrawal test procedure is being developed to provide data on duct withdrawal force loads. The refueling withdrawal tests are relatively independent of core size as long as representative duct deformations and clearances are used. Selected ducts will be pulled to determine the break-away load requirements. The tests will be conducted utilizing the same friction load pads used in the compaction tests.

An extension of the top level of the facility operating floor has been completed. This provides additional space for the instrumentation and control panel and manual operation of the insertion/withdrawal fixture. The control panel (movable) will be positioned in this section during testing. The roof of the facility enclosure has been modified to provide space to perform the withdrawal tests without compromising the clean room atmosphere.

3.3.7 Facility Modification for Full Core Tests

Prior to initiation of full core testing, some structural modifications will be made to the facility. These will include: larger jaws and improved jaw alignment system, an adjustment in the height of jaws, and the installation of new friction bushings into the lower core plates. Detail drawings of the required modifications have been completed and approved. Incorporated in the modifications are changes to provide a more efficient and more accurate method of aligning the jaw assemblies. Reconfigured alignment targets are also included in the modifications to facilitate full core testing.

Purchase requisitions for material and components have been issued. Jaw block material has arrived. The design of the friction bushings to be used in full core testing has been completed. Shipments of bushings have begun to arrive at ARD. The data acquisition system will be expanded for full core and insertion/withdrawal tests. The transition to the larger multiplexer system was completed in this reporting period. The analog tape recorder and X-Y plotter used in withdrawal force tests have been received and accepted.