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# QUARTERLY TECHNICAL PROGRESS REPORT

JULY 1 - SEPTEMBER 30, 1989

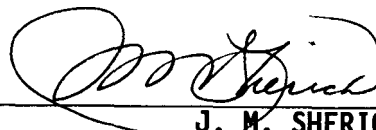
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## ABSTRACT

This quarterly technical progress report presents the tasks accomplished at the Component Development and Integration Facility during the fourth quarter of FY89. Areas of technical progress this quarter included:

- coal system development;
- seed system development;
- test bay modification;
- channel power dissipation and distribution system development;
- integrated topping cycle/proof-of-concept current controls project;
- split coal feed system;
- coal-fired precombustor;
- iron core magnet thermal protection system checkout;
- combustion carbon balance and stack gas analysis;
- coal-fired combustor support;
- 1A channels fabrication and assembly;
- arc observation project;
- dry materials transfer system controls upgrade;
- Mississippi State University post-nozzle test section;
- test operations and results;
- data enhancement;
- data analysis and modeling;
- technical papers; and
- projected activities.

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## 1.0 INTRODUCTION

The Component Development and Integration Facility (CDIF) is a major U.S. Department of Energy magnetohydrodynamic (MHD) test facility in Butte, Montana. The CDIF is operated by MSE, Inc. Within the national MHD program, MSE personnel are responsible for performing integration testing of vendor-supplied MHD power train components at the CDIF to support the goal of commercialization.

During the fourth quarter of FY89, installation of channel 1A<sub>1</sub>-C1 and AVCO-supplied current consolidation circuits was completed. Equipment checkout was also completed. Baseline testing with a new oxygen configuration was started, and iron oxide injection on cathode and anode walls was evaluated. Mississippi State University measurements were taken at the diffuser triple port walls.

## 2.0 TASK DEFINITION

- Task 1 -- Facility;
- Task 2 -- Test Hardware/Support; and
- Task 3 -- Test Operation.

### 2.1 Task 1 -- Facility

This task encompassed modifications and enhancements to the plant systems that support testing and included checkout, testing, and characterization.

Subtasks for the facility task were:

- Subtask 1A -- Coal System Development;
- Subtask 1B -- Seed System Development;
- Subtask 1C -- Test Bay Modification;
- Subtask 1D -- Channel Power Dissipation and Distribution System (CPDDS) Development;
- Subtask 1E -- Integrated Topping Cycle/Proof-of-Concept Current Controls Project;
- Subtask 1F -- Split Coal Feed System;
- Subtask 1G -- Coal-Fired Precombustor (CFPC); and
- Subtask 1H -- Iron Core Magnet (ICM) Thermal Protection System Checkout.

### **2.1.1 Subtask 1A -- Coal System Development**

The coal system development program includes modifications for resolving hardware problems in coal preparation, storage, and injection; developing optimum system operating parameters; and developing a method for on-line, instantaneous flow rate measurement.

Activities this quarter included the following:

- The new coal system main fan motor was purchased and will be installed during an upcoming plant shutdown.
- A coal recirculation line for the coal-fired precombustor (CFPC) is being installed in the coal building. This recirculation line will allow for off-line testing of items such as the CFPC pinch valve and will also provide diagnostic testing capability in the case of CFPC coal flow problems.
- Additional pressure instrumentation was installed in the CFPC and coal-fired combustor (CFC) coal lines. These instruments are used to further characterize the pressure drop of flowing coal in the dense-phase coal lines.
- A spare dense-phase injection line for the CFPC coal feed is being installed. If the CFPC coal line plugs, supply lines can be quickly switched, thus, minimizing testing downtime.
- A new type of flow control valve for CFPC coal flow is being procured. The new valve is similar to the one used in the CFC first-stage coal line, which has lasted 100+ flow hours without incident. This type of valve was commercially unavailable for some time; however, now that it is available and has proven itself, a unit will be installed in the CFPC coal line.
- Simultaneous processing of coal and MHD testing was accomplished. This is a major step toward extended duration testing.

### **2.1.2 Subtask 1B -- Seed System Development**

The following progress has been made during seed system development.

- The checkout procedure for the seed system was completed. This checkout, used to verify operation of the automatic transfer system, revealed some mechanical problems including a change of speed on the seed storage silo rotary valve and too low flow to the filter receiver bag pulse and air cannon. Installation and checkout were completed this quarter.
- A procurement specification for a new generation of capacitance-type level switch for the seed storage injector was written. If the proper type can be found, it will be installed and tested next quarter.

### **2.1.3 Subtask 1C -- Test Bay Modification**

This subtask is an ongoing effort to support the CDIF Test Program. Test bay modification will continue to evolve as testing progresses, new objectives are set, and new tests are defined.

Activity performed this quarter to support iron oxide injection is listed below.

- The solid suspension injection system underwent checkout and MHD testing this quarter. Preliminary data shows the addition of  $\text{Fe}_2\text{O}_3$  in a 50/50 mixture with oil reduces intercathode shorting.
- On-line testing to determine the optimum amount of slurry required will continue. When the optimum amount is found, the system may be modified.

### **2.1.4 Subtask 1D -- Channel Power Dissipation and Distribution System (CPDDS) Development**

The CPDDS consists of the resistive load bank, high-voltage room, inverter, and wiring from the high-voltage room to the MHD channel connectors. The following progress was made in the CPDDS this quarter.

- All of the channel connectors that were replaced with an improved type have been operationally checked during the current series of power tests, and no problems were encountered. The new connectors have eliminated many problems, including pins carrying electrode currents backing apart and causing open circuits.
- Improvements to the heating/air-conditioning system in the control area of the inverter have been completed. These improvements will provide better temperature and humidity regulation for the control electronics.
- Current control circuits were used as forward and aft power take-off current consolidators for the initial tests in the MHD power generation test series. Subsequently, the current controls were removed, and a resistive power take-off network was designed and installed. Two minor configuration changes were made to reduce voltage stresses in the aft anode region.
- High-voltage room wiring was modified to bypass the metering circuits for the segmented electrodes, which were not reinstalled on the channel.
- Efforts to upgrade inverter documentation are being finished with a print map being prepared, which lists all inverter prints alphabetically for easy reference.

### **2.1.5 Subtask 1E -- Integrated Topping Cycle/Proof-of-Concept Current Controls Project**

Design engineering activity was completed for installing Avco-supplied current controls in the Transrex (magnet power supply) room at the CDIF, and field installation has started. The design was separated into the following areas: high-voltage design, ac power distribution, cooling water piping, instrumentation, current imbalance monitoring, and structural design. The current control cabinets and their contents are designated test articles and are not part of this design effort. The cabinets were delivered from Avco, uncrated, and placed on concrete pads. AC power to the cabinets was connected, and MSE personnel assisted Avco with their initial checkout of the units. Instrumentation installation has begun, and installation of the cooling water piping is underway. Penetrations between the high-voltage room and the Transrex room were made, and cable tray runs were started for high-voltage cable installation. The current imbalance monitoring routines are to be done on the existing Data Acquisition System, and work is underway on software to test the imbalance monitoring code. An update to the site Safety Analysis Report has been written and is being submitted for approval.

### **2.1.6 Subtask 1F -- Split Coal Feed System**

The split coal feed system is operational and has proven itself during the CFPC checkout. An on-line system to correct coal flow errors due to moisture variation is being developed.

### **2.1.7 Subtask 1G -- Coal-Fired Precombustor (CFPC)**

The coal-fired precombustor checkout test series was successfully completed, which ends activity under this subtask.

### **2.1.8 Subtask 1H -- Iron Core Magnet (ICM) Thermal Protection System Checkout**

Data used to calculate the inductance of ICM taps has been stored and is being analyzed. This system is currently being used to monitor the magnet temperature during steady-state operation.

## **2.2 Task 2 -- Test Hardware/Support**

Test hardware is supplied under a Department of Energy contract and is tested at the CDIF. During the test program, hardware design modifications and repairs are accomplished by MSE personnel at the request of the component developer. Facility test hardware interface refinements are also part of this task. Subtasks for the test hardware/support task were:

- Subtask 2A -- Combustion Carbon Balance and Stack Gas Analysis;
- Subtask 2B -- Coal-Fired Combustor (CFC) Support;
- Subtask 2C -- 1A Channels Fabrication and Assembly;
- Subtask 2D -- Arc Observation Project;
- Subtask 2E -- Dry Materials Transfer System Controls Upgrade; and
- Subtask 2F -- Mississippi State University (MSU) Post-Nozzle Test Section.

### **2.2.1 Subtask 2A -- Combustion Carbon Balance and Stack Gas Analysis**

Work packages to permanently install the dry gas analysis system are on hold pending a decision from Value Engineering. Once a decision has been made, hardware changes will be made.

Work is continuing on the analysis of the off-gases for CO, CO<sub>2</sub>, hydrogen, and oxygen on a dry basis and SO<sub>2</sub>, CO, and NO<sub>x</sub> on a wet basis. Gas chromatography is being used to analyze nitrogen, hydrogen, and oxygen. A Horiba hydrogen analyzer, which allows continuous hydrogen analysis, is being evaluated. The instrument may be applicable; however, the effect on the sensitivity of the instrument by varying concentrations of the several MHD stack gas components has not been satisfactorily determined.

### **2.2.2 Subtask 2B -- Coal-Fired Combustor (CFC) Support**

A smooth-wall air inlet filler that reduced CFPC fouling was installed.

### **2.2.3 Subtask 2C -- 1A Channels Fabrication and Assembly**

The 1A<sub>1</sub>-C1 channel was installed in the test train on July 19, 1989, and underwent 21 hours 20 minutes of coal combustion time and 13 hours 15 minutes of electrical power generation time before being removed on September 7, 1989, for the repair of internal water leaks. The channel was repaired and reinstalled into the test train on September 15, 1989, and underwent an additional 14 hours 3 minutes of coal combustion time and 8 hours 9 minutes of power generation time. The total test exposure time for the individual wall segments that make up the 1A<sub>1</sub>-C1 channel is shown in Table 1.

Fabrication and assembly of the 1A<sub>1</sub>-C2 channel sidewall sections is now approximately 25 percent complete.

A supersonic section of the diffuser, which was designed and fabricated by MSE, was installed in the test train on September 15, 1989.

**TABLE 1 -- CHANNEL WALL SECTIONS AVAILABLE FOR TEST SERVICE (3-1-89)**

<u>WALL SECTION NUMBER</u>	<u>DESCRIPTION</u>	<u>COAL HRS.</u>	<u>POWER HRS.</u>
17	FORWARD PLATINUM ANODE - Comprised of platinum capped electrodes.	20:20	9:05
18	AFT PLATINUM ANODE - Comprised of platinum capped electrodes.	0	0
25	FORWARD ANODE - Comprised of explosion bonded type 446 top capping and brazed on type 446 side capping.	52:46	29:04
26	AFT ANODE - Comprised of explosion bonded type 446 top capping and brazed on type 446 side capping.	35:23	21:24
19	FORWARD CATHODE - Comprised of Cu bars with brazed on Cu-W side caps.	52:46	29:04
20	AFT CATHODE - Comprised of Cu bars with brazed on Cu-W side caps.	52:46	24:04
21-A	R-FORWARD PEG SIDEWALL - Comprised of explosion bonded type 446 capping on pegs and brazed on Cu-W caps on cathode end blocks.	35:23	21:24
30	R-AFT DIAGONAL SIDEWALL - Comprised of explosion bonded type 446 capping on anode and middle bars and Cu-W side caps on cathode end blocks.	35:23	21:24
23-A	L-FORWARD PEG SIDEWALL - Comprised of explosion bonded type 446 capping on pegs and brazed on Cu-W caps on cathode end blocks.	35:23	21:24
32	L-AFT DIAGONAL SIDEWALL - Comprised of explosion bonded type 446 capping on anode and middle bars and Cu-W sidecapping on cathode sidebars.	35:23	21:24

**2.2.4 Subtask 2D -- Arc Observation Project**

This project has been suspended.

**2.2.5 Subtask 2E -- Dry Materials Transfer System Controls Upgrade**

This subtask is being closed out; the upgrade is now in service. Follow-on reliability upgrades are scheduled for mechanical equipment and field instruments to improve automatic operation. Work will continue to complete as-built drawings, the operation and maintenance manual, the operators' manual, and system training.

**2.2.6 Subtask 2F -- Mississippi State University (MSU) Post-Nozzle Test Section**

The post-nozzle test section was removed after combustor-only testing was completed. Mississippi State University is now taking diagnostic measurements on the triple port walls in the forward subsonic section of the diffuser.

## **2.3 Task 3 -- Test Operation**

The subtasks for the test operation task were:

- Subtask 3A -- Test Operations and Results;
- Subtask 3B -- Data Enhancement; and
- Subtask 3C -- Data Analysis and Modeling.

### **2.3.1 Subtask 3A -- Test Operations and Results**

Coal-fired combustor (CFC) checkout continued, and baseline testing started. For the baseline tests, the combustor was integrated in the operational configuration. The second stage was refurbished, and the second-stage oxygen was configured for an effective length/height of 2.7 with 12-port horizontal injection. For the CFC checkout tests, channel 1A<sub>1</sub>-C1 was fully integrated into the facility, excluding electrode wiring. For baseline testing, the channel was configured for power generation in the diagonal mode; the two forward sidewalls were pegwalls. Mississippi State University diagnostic equipment was installed in the triple port diffuser walls for most of the tests. During the quarter, sixteen tests were performed; seven tests were successful. Table 2 outlines tests run during the quarter.

The following activities were accomplished:

- Demonstrated functional performance of seed and iron oxide slurry systems and consumable process flow delivery into the combustor.
- Continued to establish baseline fouling condition for redesigned, smooth-walled filler assembly at nominal stoichiometry and evaluated dependence of individual filler panel heat loss on fouling condition.
- Obtained baseline heat flux data for second-stage individual frames and the entire CFC at nominal power operating conditions.
- Obtained baseline stack gas emission data of carbon closure for power conditions.
- Continued evaluating additional system variables including oil burner performance, filler heat flux, refractory performance, and sleeve heat flux.
- Accomplished initial testing of the channel in conjunction with the CFPC for both plasma conductivity measurement and power generation operations.
- Evaluated the performance of the power take-off current consolidation circuits.

TABLE 2 -- MHD TESTS

DATE	TEST NO.	TEST OBJECTIVE	COAL BURN TIME (hr min)	ENERGY GENERATED (MW hr)	PEAK POWER (MWe)	POWER RUN TIME (hr min)	COMMENTS
7/20/89	89-CFC-13	<ol style="list-style-type: none"> <li>1) Demonstrate functional performance of seed and iron oxide slurry systems and consumable process flow delivery into the combustor before conductivity and power testing.</li> <li>2) Continue to establish baseline fouling condition for redesigned, smooth-walled filler assembly at nominal stoichiometry. Evaluate dependence of individual filler panel heat loss on fouling condition.</li> <li>3) Obtain baseline heat flux data for second-stage individual frames and the entire CFC at nominal power operating conditions.</li> <li>4) Achieve smooth startup and shutdown and maintain combined-stage operation at 50 MWt for a minimum duration of 7 hours, consumables limiting. Operation will vary N/O (global) from 0.76 to 0.70.</li> <li>5) Obtain baseline stack gas emission data for carbon closure prior to power conditions.</li> <li>6) Continue evaluating additional system variables including oil burner performance, filler heat flux, refractory performance, and sleeve heat flux.</li> <li>7) Provide thermal test of rebuilt channel and obtain channel operation heat flux and channel pressure data.</li> <li>8) Support MSU diagnostic equipment measurements.</li> </ol>	00:08	N/A	N/A	N/A	Test objectives were not met. Test startups were smooth, but because the combustion air compressor kept tripping off-line, testing could not be kept on-line.
7/25/89	89-CFC-14	<ol style="list-style-type: none"> <li>1) Same as 89-CFC-13</li> </ol>	02:25	N/A	N/A	N/A	Test objectives were partially met. Startups were smooth, and systems generally operated well. However, incorrect slag tank thermocouple readings for vent line coolant temperatures resulted in the hose overheating and melting. Shutdown of the test was required for repair.
8/7/89	89-DIAG-1	<ol style="list-style-type: none"> <li>1) Accomplish initial testing of the channel in conjunction with the CFPC for both plasma conductivity measurement and power generation operations.</li> <li>2) Evaluate the performance of power take-off current consolidation circuits.</li> <li>3) Obtain baseline heat flux and power data with N/O = 0.70; Phi 1 = 0.55; Phi 2 = 0.90, 0.95, 1.00, and 1.05 (without iron oxide); and mixing of L/H = 2.7.</li> <li>4) Continue evaluation of the filler section fouling, plant systems operation, and CFPC flame stability using the flame detector.</li> <li>5) Support MSU diagnostic equipment measurements.</li> </ol>	00:39	N/A	N/A	N/A	Test objectives were not met. Combustor startups were smooth, and most systems operated well; however, the conductivity power supply failed during the startup portion of the test. The rest of the test was preempted when the CFPC pinch valve ruptured and allowed coal to leak into the test bay. Consequently, testing was shutdown for repairs.

TABLE 2 - - MHD TESTS (CONT'D)

DATE	TEST NO.	TEST OBJECTIVE	COAL BURN TIME (hr min)	ENERGY GENERATED (MW hr)	PEAK POWER (MWe)	POWER RUN TIME (hr min)	COMMENTS
8/8/89	89-DIAG-2	1) Same as 89-DIAG-1	00:01	N/A	N/A	N/A	Test objectives were not met. Combustor startups were smooth, and most systems operated well; however, CFPC coal flow was lost shortly after CFPC startup. CFPC coal flow could not be reinitiated, and testing was shutdown to unplug the coal line and investigate the cause of the plugging.
8/9/89	89-DIAG-3	1) Same as 89-DIAG-1	00:12	N/A	N/A	N/A	Test objectives were not met. Combustor startups were smooth, and most systems operated well; however, CFPC coal flow could not be maintained. The testing was shutdown for further troubleshooting of coal flow problems.
8/10/89	89-CFC-15	Initially: 1) Verify the ability of the coal system to flow coal to the CFPC.  Subsequently: 1) Same as 89-DIAG-1	05:00	4.42	1.43	04:12	Test objectives were partially met. Combustor startup was smooth. As the test continued, several operational problems were discovered that required post-test evaluation, including the CFPC coal flow, the conductivity power supply, the seed flow, and the iron oxide slurry flow. For the first time, the new power take-off configurations were checked and appeared to work well. After the test, an internal inspection of the channel revealed a low-level leak at anode 56; therefore, the channel was converted to low-pressure cooling so testing could continue without having to remove the channel for repair. Testing was shutdown when adequate seed flow could not be maintained.
8/16/89	89-DIAG-4	1) Obtain baseline heat flux and power data with N/O = 0.70; Phi 1 = 0.55, 0.53, and 0.50; Phi 2 = 0.90, 0.95, 1.00, and 1.05; mixing of L/H = 2.7; 12-port horizontal oxygen injection.  2) Continue evaluation of the filler section fouling, plant systems operation, and CFPC flame stability using the flame detector.  3) Support MSU diagnostic equipment measurements.  4) (Optional) Evaluate reduced CFPC flame temperature operations.	06:22	6.39	1.66	04:43	Test objectives were met. Systems generally operated well. Although somewhat erratic early in the test, coal flow was maintained at the requested flow rate during the power portion of the test. Iron oxide slurry injection on the cathode worked well.
8/22/89	89-DIAG-5	1) Obtain baseline heat flux and power data with N/O = 0.70; Phi 1 = 0.55; Phi 2 = 0.95; mixing of L/H = 2.7; 12-port horizontal oxygen injection; varied iron oxide injection on cathode wall; and varied seed flow rates.  2) Continue evaluation of the filler section fouling, plant systems operation, and CFPC flame stability using the flame detector.  3) (Optional) Evaluate seed velocity considerations at L/H = 2.7.  4) (Optional) Evaluate reduced CFPC flame temperature operations.	00:02	N/A	N/A	N/A	Test objectives were not met. CFPC coal flow could not be established, or when it was established, it could not be maintained. No plugging was found during a post-test inspection of the coal line. Troubleshooting revealed no obvious reason for the CFPC coal flow difficulties.

TABLE 2 -- MHD TESTS (CONT'D)

DATE	TEST NO.	TEST OBJECTIVE	COAL BURN TIME (hr min)	ENERGY GENERATED (MMW hr)	PEAK POWER (MWe)	POWER RUN TIME (hr min)	COMMENTS
8/23/89	89-DIAG-6	1) Same as 89-DIAG-5	00:02	N/A	N/A	N/A	Test objectives were not met. CFPC coal flow could not be established, or when it was established, it could not be maintained. A post-test inspection of the coal line revealed no blockage. Troubleshooting revealed no obvious reason for CFPC coal flow difficulties. Different CFPC coal flow startup procedures were planned for the next test.
8/25/89	89-DIAG-7	1) Same as 89-DIAG-5	00:55	0.01	0.62	00:15	Test objectives were not met. For many of the test starts, CFPC coal flow could not be established, or when it was established, it could not be maintained. Finally, when the coal flow was established and maintained, the test was tripped due to an arc detection. A post-test inspection revealed a short in a channel pressure port.
8/30/89	89-DIAG-8	1) Same as 89-DIAG-5	00:30	0.00	0.00	00:11	Test objectives were not met. For many of the test starts, CFPC coal flow could not be maintained. The test was shutdown when attempts to clean the coal line and coal flow failed. A post-test inspection revealed plugging in the dense-phase portion of the CFPC coal line. The line was washed out and dried, and one portion of the line was replaced when the plug could not be removed.
9/6/89	89-DIAG-9	1) Same as 89-DIAG-5	05:04	3.72	1.89	03:54	Test objectives were partially met. All systems operated well. For the first time, coal was processed on-line during this test. The processing went well, and newly processed coal was used during the test. This sequence was planned to check out some aspects that are required for the upcoming 16- to 24-hour test. A new record peak power level--1.89 MWe--was achieved during this test.
9/18/89	89-REST-1	1) Checkout the wiring of the aft power take-off in the resistively consolidated configuration. 2) Obtain reduced CFPC flame temperature startup heat flux data. 3) Determine maximum seed flow rate.	01:02	0.24	1.07	00:33	Test objectives were met. All systems and the reduced flame temperature startup operated well. The repaired conductivity power supply was checked out. Wiring anomalies were noted in the resistively consolidated configuration and will be repaired before the next test.
9/19/89	89-DIAG-10	1) Obtain baseline heat flux, conductivity, and power data with N/O = 0.70; Phi 1 = 0.55; Phi 2 = 0.95; mixing of L/H = 2.7; 12-port horizontal oxygen injection; and varied iron oxide injection on cathode wall. 2) Obtain reduced flame temperature startup heat flux data. 3) Continue evaluation of the filler section fouling, plant systems operation, and CFPC flame stability using the flame detector. 4) Support MSU diagnostic equipment measurements.	01:09	N/A	N/A	00:00	Test objectives were not met. Testing was terminated when the requested seed flow could not be attained.

TABLE 2 -- MHD TESTS (CONT'D)

DATE	TEST NO.	TEST OBJECTIVE	COAL BURN TIME (hr min)	ENERGY GENERATED (MW hr)	PEAK POWER (MWe)	POWER RUN TIME (hr min)	COMMENTS
9/19/89	89-DIAG-10	5) (Optional) Obtain baseline heat flux, conductivity, and power data with N/O = 0.70; Phi 1 = 0.55; Phi 2 = 0.95; mixing of L/H = 2.7; 12-port horizontal oxygen injection; and varied seed flow rates.  6) (Optional) Evaluate seed velocity considerations at L/H = 2.7.  7) (Optional) Obtain Phi sweep data at reduced CFPC flame temperature operations.  8) (Optional) Evaluate iron oxide injection on the anode wall.  9) (Optional) Obtain baseline data at N/O = 0.80.					
9/20/89	89-DIAG-11	Same as 89-DIAG-10	06:21	6.88	1.74	05:01	Test objectives were partially met. All systems operated well with the exception of the seed system. Iron oxide was run for a five-hour duration with no noticeable decrease in power output.
9/28/89	89-DIAG-12	1) Obtain heat flux, conductivity, and power data with varied iron oxide flow rates on the cathode wall and the anode wall.  2) Obtain baseline heat flux, conductivity, and power data with N/O = 0.70; Phi 1 = 0.55; Phi 2 = 0.95; mixing of L/H = 2.7; 12-port horizontal oxygen injection; and iron oxide injection on cathode wall.  3) Obtain reduced flame temperature startup heat flux data.  4) Continue evaluation of the filler section fouling, plant systems operation, and CFPC flame stability using the flame detector.  5) Support MSU diagnostic equipment measurements.  6) (Optional) Obtain baseline heat flux, conductivity, and power data with N/O = 0.70; Phi 1 = 0.55; Phi 2 = 0.95; mixing of L/H = 2.7; 12-port horizontal oxygen injection; and varied seed flow rates.  7) (Optional) Evaluate seed velocity considerations at L/H = 2.7.  8) (Optional) Obtain Phi sweep data at reduced CFPC flame temperature operations.  9) (Optional) Obtain data at increased N/O ratios and L/H = 2.7.  10) (Optional) Evaluate increased iron oxide injection on the cathode wall.	05:31	2.46	1.89	02:35	Test objectives were partially met. All systems operated well with the exception of the seed system. Seed flow rates were not consistent and will be investigated before further testing.

- Obtained baseline heat flux and power data with N/O = 0.70; Phi 1 = 0.55; Phi 2 = 0.90, 0.95, 1.00, and 1.05 (without iron oxide); and mixing of L/H = 2.7.
- Varied iron oxide injection on cathode wall.
- Varied iron oxide injection on anode wall.
- Obtained reduced flame temperature startup heat flux data.
- Supported Mississippi State University diagnostic equipment measurements.
- Obtained baseline heat flux, conductivity, and power data with N/O = 0.70; Phi 1 = 0.55; Phi 2 = 0.95; mixing of L/H = 2.7; 12-port horizontal oxygen injection; and varied seed flow rates.
- Achieved new maximum peak power level of 1.89 MWe.

### 2.3.2 Subtask 3B -- Data Enhancement

No new activity has taken place within this subtask during this quarter.

### 2.3.3 Subtask 3C -- Data Analysis and Modeling

Preliminary analysis of CDIF test data, which uses a recently developed model, indicates the CDIF generator, which is configured in diagonal mode, is probably operating below its optimal power condition. It appears the channel was designed to operate at an equipotential overlap of  $N = 15$ , which would be near optimum if slag leakage effects were small. However, in coal-fired generators, slag polarization is severe and generates large axial leakage currents and large transverse nonuniformity factors over channel cross sections (including slag layers). Effectively, slag polarization has forced the channel to operate in an off-design mode. An all pegwall channel would be needed to fully test the effects of a changed overlap pitch. Further analysis of test data needs to be done before any testing of variations in the overlap pitch can be considered.

The MSE-designed nozzle test window bar is designed to provide access passage for Mississippi State University testing equipment. Computer analyses of the cooling water flow, critical heat flux, and temperature distribution for this nozzle test window bar were performed to verify component integrity under operating conditions. The cooling water mass-flow rate and velocity were predicted by a one-dimensional flow analysis, the critical heat flux was calculated by two different methods, and the COSMOS PC finite element package calculated the temperature distribution in the bar design. The results indicate the nozzle test window bar design is safe at the specified modeling conditions. Refer to the MSE report "Critical

Heat Flux and Finite Element Temperature Distribution Calculation for the Nozzle Test Window Bar" for further information.

The coal-fired combustor process flow code (CFCPFC) program, which is used to establish the required process flows for all tests at the CDIF, was revised to reflect the changes made for the installation of the coal-fired precombustor. The equations used in this program (V.1.03) are based on TRW's "50-MW<sub>T</sub> Coal-Fired Combustor User's Manual" (memo dated June 19, 1989). The program and complete user's manual (including user instructions, equations, and flow charts) have been distributed to TRW and MSE personnel.

The CFCPFC program provides two operation modes. The user can input process flow variables (e.g., coal flow rate, oxygen flow rate, etc.) to calculate the combustor operating parameters (e.g., preheat temperatures, equivalence ratio, etc.), or the user can input combustor operating parameters to obtain process flow variables. The latter calculation involves finding the solution to a system of nonlinear equations that has no analytical solution; the numerical method is implemented in the program to get the solution. Other features include the capability to input the composition of the coal, save and load data files, print the output, put comments with the data, and output certain data to the disk for future editing.

With the helpful menus and well-designed screens, the CFCPFC program is very easy to use. The user's manual provides more in-depth operational information to supplement the on-screen menus. Technical information is provided in the manual's appendix and can be used to modify the code for other possible process flow applications.

### 3.0 TECHNICAL PAPERS

Two papers were presented at the 24th Intersociety Energy Conversion Engineering Conference held August 6-11, 1989, in Washington, D.C.

Papers presented were:

- Coal-Fired MHD Topping Cycle Hardware Development and Test Progress at the Component Development and Integration Facility by A. T. Hart, I. E. Stepan, R. J. Glovan, and J. M. Richards, and
- Axial Current Conduction in Polarized Slag Layers On Coal-Fired MHD Generator Walls by J. Lohrasbi and D. Lofftus.

#### 4.0 PROJECTED ACTIVITIES

Facility (Task 1) activities planned for the first quarter of FY90 include:

- upgrading the iron oxide slurry system to increase system capacity and to continue assessing system requirements;
- continuing installation of the current controls; final installation is expected in the second quarter of FY90;
- initiating efforts for data reduction of transient information on the iron core magnet thermal protection system;
- modifying and testing the on-line coal flow control valves to provide enhanced duration capability;
- completing modifications to support a proof-of-concept MHD coal fines test; and
- completing construction and recommissioning the dry materials transport vessel in its new, permanent location.

Test hardware support (Task 2) activities planned for the first quarter of FY90 include:

- completing assembly of the 1A<sub>1</sub>-C2 channel and
- completing refurbishment of platinum capped anode wall sections 17 and 18, and installing them into the 1A<sub>1</sub>-C1 channel.

Test operations (Task 3) activities planned for the first quarter of FY90 include:

- performing baseline testing;
- performing a duration test of 16+ hours;
- performing a fine coal test;
- performing a test with higher N/O ratio in the second stage (20 percent nitrogen and 80 percent oxygen);
- installing a platinum anode and testing with iron oxide;
- installing AVCO-supplied current controls;
- installing the 1A<sub>1</sub>-C2 channel; and
- continuing Mississippi State University diagnostic measurements at diffuser triple port walls.