TIDD PFBC Demonstration Project

**Quarterly Report
April 1 - June 30, 1993**

July 1993

Work Performed Under Contract No.: DE-FC21-87MC24132

**For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia**

**By
American Electric Power Service Corporation
Columbus, Ohio**

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MASTER

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS USED IN THIS REPORT

AARP	Annunciator Alarm Response Procedures
AB	ASEA Babcock - A business partnership between a subsidiary of ABBC and the Babcock & Wilcox Company (USA)
AEP	American Electric Power Company, Inc.
AEPSC	American Electric Power Service Corporation - A subsidiary of AEP
AFC	Approved for Construction
AFL	Approved for Layout
ABBC	ABB Carbon - A subsidiary of ASEA-Brown Boveri (subcontractor)
AOP	Abnormal Operating Procedure
B&W	The Babcock & Wilcox Company (subcontractor)
BWCC	The Babcock & Wilcox Construction Company (subcontractor)
BOP	Balance of Plant
CBI	Chicago Bridge and Iron, Inc. (subcontractor)
CSWD	Cable Schematics Wiring Drawings
DOE	Department of Energy (United States)
DRC	Design Review Committee
E&SC	Electrical Equipment Service Corporation (subcontractor)
ECP	Engineering Control Procedure
EMP	Environmental Monitoring Plan
EOP	Emergency Operating Procedure
EPA	Environmental Protection Agency
ESP	Electrostatic Precipitator
FAT	Net 90 - Factory Acceptance Test
GSU	Generator Step-Up Transformer
HVAC	Heating, Ventilating & Air Conditioning
I&C	Instrumentation & Control
IOI	Initial Operating Instructions
MCR	Material Control Record
MCS	Management Command System

GLOSSARY OF ACRONYMS AND ABBREVIATIONS USED IN THIS REPORT

MCC	Motor Control Center
MED	Mechanical Engineering Division
NDE	Nondestructive Examination
NEMA	National Electric Manufacturers Association
NOP	Normal Operating Procedure
NOVAA	North Ohio Valley Air Authority
NPDES	National Pollutant Discharge Elimination System
OEPA	Ohio Environmental Protection Agency
OCDO	Ohio Coal Development Office - A part of Ohio Department of Development
OPCo	Ohio Power Company
PES	Plant Electrical Systems
PFBC	Pressurized Fluidized Bed Combustion
PMP	Project Management Plan
POPS	Plant Operations and Performance System
ppb	Parts Per Billion
PTI	Permit to Install
PTO	Permit to Operate
PWHT	Post-Weld Heat Treatment
RDR	Request for Drawing Revision
RFQ	Request for Quotation
SD-0	System Description (Rev. 0)
SD-1	System Description (Rev. 1)
SD-2	System Description (Rev. 2)
SD-2.5	System Description (Rev. 2.5)
SD-3.0	System Description (Final)
SPCC	Spill Prevention Control & Countermeasures

I. INTRODUCTION AND SUMMARY

This is the 25th Technical Progress Report submitted to the Department of Energy in connection with the cooperative agreement between the DOE and the Ohio Power Company for the Tidd PFBC Demonstration Plant. This report covers the period from April 1, 1993 to June 30, 1993.

Major activities during this period involve:

- The unit has been out of service since early February due to the failure of the gas turbine. The gas turbine was repaired during this quarter and unit was started on June 29, 1993.
- The unit was operated for a total of 32 hours (including gas turbine air prewarming). There were three gas turbine starts, two bed preheater starts, and one operating period with coal fire. The peak gross output of 13 MWH was achieved for the period of 2200 to 2300 hours on June 30, 1993.
- During the quarter, total gross generation was 75 MWH, and coal consumption was 107 tons.
- New individual ash lines from cyclones to the economizer were installed.
- New sparge ducts were installed along with sparge duct end fluidization piping and valves.
- Expansion joint heaters and insulation for hot gas clean-up system were installed.

Major items planned for the next period include:

- Installation of SO₂ analyzer equipment.
- Continuation with the operation and testing of the unit after all the current GT problems are resolved.

II. DESIGN AND PERMITTING

A. Mechanical Engineering Division

1. Engineering and Design

The Mechanical Engineering Division has been involved in the following engineering and design activities during this report period:

- **Secondary Ash Removal System:**

During the first quarter, the decision was made to totally replace the secondary ash removal system.

As the second quarter began, work was underway on installation of six independent ash lines. Each line is routed from the secondary dip leg, exits the combustor vessel, and then goes directly to the economizer discharge duct. All piping inside the combustor is 3/4 inch diameter piping. The pipe has exterior fins to reduce the hot gas/ash stream temperature to acceptable levels before the gas stream exists the combustor. Once outside the combustor, the ash line increases to 1 inch diameter and then 1-1/4 inch diameter before it enters the economizer duct.

Also installed outside the combustor in each line were isolation and blowdown ball valves. If the ash lines plug in service, these valves will permit the ash line to be isolated and either blown down or blown back into the dip leg, thus removing the ash line blockage.

During the operational run at the end of the second quarter, the ash lines operated flawlessly. No ash line pluggage occurred at start-up or during the run.

An inspection of the dip legs in early July indicated no significant ash build-up in the dip legs. For the first time ever, the unit was shut down and could have been restarted after an outage without vacuum cleaning ash out of the dip legs.

- Freeboard SO₂ Sampling

It has been theorized that a high concentration of SO₂ exists in the plumes at the fuel nozzle outlets. This is due to high localized release of organically bound sulfur that forms as the volatiles burn. The existence of the volatile plumes was documented early in the test program through freeboard SO₂ mapping. It follows that if locally large amounts of SO₂ exist in these plumes, it would have a major impact on the design of the sorbent distribution system in future commercial plants.

In order to determine whether such high SO₂ concentration exists, a new freeboard gas sampling system has been designed. It will sample gas at six points in the boiler freeboard. All tubing external to the combustion vessel will be heat traced to maintain the sample above the acid dewpoint. A new SO₂ analyzer has been purchased to take the measurements. This equipment is expected to be operational by the first week of August, 1993.

- Gas Turbine

Stress Technology, Inc. (STI) was in Columbus on June 23, 1993 to make a presentation of the gas turbine LPT blade failure analysis. In attendance were representatives from AEPSC, Ohio Power Tidd Plant, ABB Stal, and ABB Carbon. The presentation confirmed that the failure was due to high cycle fatigue from the 6th ND first mode blade resonant frequency vibration. STI's study of the ABB revised blade design shows a 20% reduction in the combined steady and dynamic

stress levels. It is expected that the reduced stress would increase the blade life from operation at the resonant frequency significantly. An LPT blade telemetry test has been planned for unit start-up to confirm the reduced stress on the LPT blading. The testing will also help develop a safe operating curve to avoid any potential blade resonant frequencies.

The gas turbine repairs from the LPT blade failure were completed and the turbine was test rolled on June 28, 1993. A balance weight was installed at the inlet of the HPT due to No. 3/4 bearing vibration. The turbine was again test rolled on June 29, 1993. The vibration levels were acceptable and the unit was started on June 29, 1993 to begin the telemetry testing of the LPT blading.

2. Meetings

The Tidd Test Committee met on May 27, 1993 to determine the unit test plan following the GT repair outage.

3. Phase III-Testing and Data Collection

No unit testing was performed during the second quarter of 1993 due to the GT repair outage.

B. Instrumentation and Controls Division

1. Balance of Plant Design Major Systems Work on or Completed

- The POPS system was updated to calculate the purge air flow entering each C2 cyclone dip leg and the ash/ gas/ air flow down each C2 ash line. Two tractor recorders have been installed to monitor temperatures on the piping. These temperatures will be monitored through the POPS system.

C. Environmental Engineering Division

- All monthly and quarterly environmental monitoring reports were filed with the North Ohio Valley Air Authority and Ohio EPA, as required.
- The DOE's Environmental Monitoring Plan (EMP) requires quarterly reports be filed within 60 days of the quarter's end. In compliance with that requirement, the EMP quarterly report for the first quarter (January - March), 1993 was submitted to DOE in late May.
- The ground water monitoring wells around the PFBC ash disposal area were sampled in April for the second quarter data. Since the PFBC unit was not operating during the second quarter, no other waste streams in the Environmental Monitoring Plan were sampled.

D. Electrical Engineering Division

- No major electrical engineering activities pertinent to this plant were performed during the period from April 1 through June 30, 1993.

E. Civil Engineering Division

- No major civil engineering activities for this plant were performed during the reporting period.

III. PROJECT MANAGEMENT AND CONSTRUCTION

A. Construction Activities

The significant construction activities performed during the second quarter of 1993 related to the major outage-related work which was started in the previous quarter. The following is a summary of the work performed.

1. Gas Turbine

A purchase order was issued to ABB Carbon to provide replacement components for the gas turbine. On-site delivery of the components started on May 24, 1993 and was completed on June 7, 1993. Reassembly of the gas turbine was performed by the plant personnel and the unit was ready for start-up by late June.

2. Sparge Duct Assemblies

A purchase order was issued to CVI, Inc. covering fabrication of new sparge duct assemblies. On-site delivery of the sparge duct assemblies was started on May 18, 1993 and was completed on June 11, 1993. The associated site construction activities were performed by B&W Construction Company and the work was completed on June 18, 1993.

3. Expansion Joint Heat Tracing System

This work was performed for the Hot Gas Clean-up Project under Cooperative Agreement DE-FC21-89MC26042. Separate quarterly reports are submitted to the DOE covering the project details.

All construction work performed during the outage supported re-start of the unit by the end of June.

IV. TIDD PFBC PLANT OPERATIONS

A. Operations

The following is a summary of accumulated operating data for the period April 1, 1993 through June 30, 1993:

Steam Turbine Generation	75 MWH
Gas Turbine Generation	0 MWH
Total Gross Generation	75 MWH
Peak Generation for One Hour	13 MWH
Total Oil Fire Operating Time	8 Hours
Total Coal Fire Operating Time	6.5 Hours
Total Coal Injected	107 Tons
Total Sorbent Injected	47 KLB

The unit was operated for a total of 32 hours (including gas turbine air warming). There were three gas turbine starts, two bed preheater starts, and one operating period with coal fire. The peak gross output of 13 MWH was for the period of 2200 - 2300 hours on June 30, 1993.

The unit was out of service at the beginning of the quarter to repair the gas turbine. The unit was released for start-up on June 26, 1993 but was required to remain out of service until June 29, 1993 to allow completion of stack testing at Cardinal Unit No. 1.

The hot gas clean-up system was restored for service for this start-up.

1. Start-up TD-SU-93-04-01 June 26 - July 3, 1993

The purpose of the start-up was to obtain strain gauge data from the new LPT blades.

The combustor was released by the Maintenance Department at 1518 hours on June 25, 1993. Water circulation was started for boiler circuit warming.

The gas turbine was released to Operations at 2003 hours on June 26, 1993. Gas recirculation warming was started at 2330 hours.

Testing at Cardinal Unit No. 1 prevented rolling of the gas turbine until 0227 hours on June 28, 1993 at which time a "window" in Cardinal testing allowed for a roll-up to check for vibration. The gas turbine generator was paralleled at 0239 hours, and valves opened to combustor at 0251 hours. The combustor was pressurized and checked for external leaks, etc., then the gas turbine was tripped at 0657 hours for cool down to install balance weight due to vibration on No. 3/4 bearing and to allow Cardinal to complete their testing.

After the cool down on the HPT, a balance weight was installed. After the testing at Cardinal Unit No. 1 was completed for the day, the gas turbine was rolled at 0202 hours on June 29, 1993 to check vibration. The gas turbine generator was paralleled at 0218 hours. Vibration levels were acceptable and the gas turbine was tripped at 0226 hours. The unit was ready to proceed with the start-up when Cardinal Unit No. 1 testing was complete. Cardinal released the stack for Tidd start up at 2000 hours on June 29, 1993. The gas turbine was rolled at 2059 hours, paralleled at 2110 hours, and the valves

opened and air flow established through the combustor and APF at 2119 hours.

The bed preheater was lit at 0908 hours on June 30, 1993.

The steam turbine was rolled at 1240 hours. After testing the overspeed trip with oil and rerolling the steam turbine, a combustor trip was suffered at 1329 hours due to low boiler circulating flow. The trip was reset and the bed preheater initiated at 1353 hours. The steam turbine was rolled at 1459 hours and paralleled at 1553 hours.

At 1727 hours a coal fire was established.

While increasing air flow, higher than normal vibration was noticed at the gas turbine No. 5 bearing. LPT speed was held at approximately 4400 RPM until enough inlet guide vane position was available to make the ramp to 4650 RPM.

Bed level was increased to approximately 45 inches and maintained there to build bed material inventory. After accomplishing this, the bed level was increased and boiler once through operation achieved at 0855 hours on July 1, 1993.

The gas turbine intercooler ran out of cooling capacity on the evening of July 1, 1993 at a bed height of 108 inches (maximum attainable bed height).

The unit load and air flow was then manipulated for the LPT strain gauge testing.

While the bed height was being held at 50 inches for more LPT testing the next day, the steam turbine was removed from service at 2231 hours on July 1, 1993 and the scheduled overspeed tests accomplished.

Following the overspeed tests, the steam turbine generator was paralleled at 0301 hours on July 2, 1993.

Testing continued on the LPT vibration analysis. Bed level and air flow was manipulated to get the required conditions for the various phases of the testing.

Bed level was raised on the evening of July 2, 1993 until the intercooler again ran out of cooling capacity with the following conditions:

Bed Level	116 inches
Bed Temp.	1540 degrees
Air Flow	640 kpph
LPT Speed	5397 RPM
Ambient Temp.	80 degrees F.

Bed level was reduced to complete the last of the LPT vibration analysis tests.

Following this last test, bed level was lowered to 80 inches and the combustor tripped at 0505 hours on July 3, 1993.

The bed level was continued to be lowered to 0 inches and the gas turbine removed from service at 0948 hours for the cool down period to change the telemetering batteries and change the strain gauge wiring.

B. Maintenance

1. Outage TD-OT-93-03 February 9 - June 26, 1993

This outage began in the first quarter.

Gas Turbine:

The cold gas bypass valves were removed, stems machined and valves seats revised, as per ABBC.

The LPT outlet duct housing damage from the blade failure was repaired.

The repaired LPC, LPT, Intermediate housing, HPT, HPC, and LPT inlet guide vane assembly were reassembled.

Installed telemetering equipment for the LT blade strain gauge testing.

Circulated and filtered the lube oil and control fluid systems.

Cyclone Ash:

Removed existing secondary ash removal system and installed new individual ash lines from the cyclones to the economizer.

Replaced V-102 pressure reducer.

Replaced bearings on cyclone separator rotary feeder.

Replaced 40 leaking flange gaskets on the primary cyclone ash removal system piping.

Sorbent Preparation:

Removed the target plate above the drying mill.

Relined the cyclone separator with ceramic lining. Replaced the lower cone area with Hardex 500 material.

Sorbent Injection:

Padwelded the transport piping downstream of HCV-B840 and HCV-B850 (isolation valves).

Combustor:

Replaced the sparge ducts.

Replaced bed zone liner tiles as needed and at areas of modification from sparge duct end fluidization.

Installed sparge duct end fluidization piping and valves to prevent damage to sparge ducts.

Replaced several bed zone thermocouple wells.

Installed new fuel nozzle inserts of RA-333 material.

Bed Preheater:

Changed from ring header distribution headers to "T" type distribution headers on oil and air piping to allow inspection/repairs to burner nozzles.

Hot Gas Clean-up:

Modified piping to tie in HGCU to PFBC.

Replaced 15 ball valves on the backpulse skid and installed revised mounting kits on the automatic ball valves.

Added a back-up regulator to the instrument purge air tank.

Replaced the backpulse compressor 4th stage cylinder sleeve.

Installed expansion joint heaters and insulation.

Installed pneumatic vibrator for the APF liner at the ash outlet.

Installed No. 11 primary cyclone spoiling air system to facilitate HGCU testing.

Miscellaneous:

Replaced five firebox tubes on the auxiliary boiler.

Rebuild precipitator flyash removal lock hopper valves HCV-J600 and HCV-J610.

Made final chute connection to fuel prep from the sorbent fines admission system.

Installed new motor sheave and belts on the splitting air compressor to reduce compressor speed.

Installed fire protection on coal system bag houses.

C. Performance

Installed fail-safe logic and hardware for HCV-P100 (bed preheater bypass damper).

Installed logic and pick-ups for one additional speed indication on both the HP and LP gas turbine shafts.

Installed and checked out controls for HGCU expansion joint heaters.

Installed and checked out instrumentation for the new secondary ash removal system.

Performed annual DC lube oil pump tests, critical control valve transfer tests, and N-90 trip bus checks.

Did extensive testing of Bailey N-90 system communication problems.

V. MANPOWER REPORT

As of June 30, 1993, AEPSC actual work-hours for the Phase III accounted for 22.5% of the total budget of 135,098. Figure 1 represents the budget versus actual work-hours for this phase.

Figure 1

	1Q91	2Q91	3Q91	4Q91	1Q92	2Q92	3Q92	4Q92	1Q93	2Q93	3Q93	4Q93	1Q94	2Q94	3Q94	4Q94
Budget	10.6	21.7	31.3	39.4	47.7	54.1	60.4	66.8	73.1	78.7	84.3	89.7	93.3	96.5	99.8	100.0
Actual	0.7	3.6	7.1	10.1	14.4	17.8	21.6	25.2	29.5	32.5						

VI. COST DATA

1. Project Cost Status

The actual cost shared expenditures during the Second Quarter 1993 were \$1,979,185 versus \$3,334,000 forecasted. As of June 30, 1993, the cumulative cost shared expenditures for Phase I, II, and III were \$168,141,818.

Figure 2 depicts the cumulative expenditure forecast for the project from Calendar Year (CY) 1986 to CY 1994. This cash flow curve represents the entire project, all three phases, including expenditures that are not cost shared with DOE.

Figure 3 is a projection of the quarterly expenditures for all participants. It also identifies the actual quarterly expenditures through the Second Quarter 1993.

The following table summarizes the project expenditures as of June 30, 1993, of all participants.:

	<u>DOE</u>	<u>OCDO</u>	<u>OPCO</u>	Total Expended as of <u>6/30/93</u>
<u>Phase I</u>				
Design &				
Permitting	\$ 7,000,000	\$ 5,000,000	\$ 9,539,183	\$ 21,539,183
<u>Phase II</u>				
Construction &	\$47,000,000	\$ 5,000,000	\$ 69,957,156	\$121,957,156
Start-up				
<u>Phase III</u>				
Operation, Data				
Collection,				
Reporting &				
Disposition	<u>\$ 4,481,276</u>	<u>\$ -</u>	<u>\$20,164,203</u>	<u>\$ 24,645,479</u>
Total:	\$58,481,276	\$10,000,000	\$99,660,542	\$168,141,818

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DOE Instrument DE-FC21-87 MC24132.000

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Second Quarter CY 1993

Figure 4 is the Phase III DOE quarterly actual and projected expenditures.

2. Contracts Awarded During Second Quarter 1993

Major contractual commitments issued during this reporting period totalled \$46,476 and are summarized as follows:

<u>Purchase Order</u>	<u>Description (Contractor)</u>	<u>Contracted Costs</u>
28244-761-3	Secondary Ash Isolation Ball Valves (Simco Controls)	\$ 29,976
28403-760-3	Ultraviolet Analyzer for SO ² Measurement (Anarad, Inc.)	<u>\$ 16,500</u>
	Total	\$ 46,476

Figure 2

	(in Millions)																					
	Thru 88	1Q89	2Q89	3Q89	4Q89	1Q90	2Q90	3Q90	4Q90	1Q91	2Q91	3Q91	4Q91	1Q92	2Q92	3Q92	4Q92	1Q93	2Q93	3Q93	4Q93	1Q94
Forecast	68.7	74.0	93.4	115.4	130.7	140.1	146.4	154.8	156.9	163.1	166.5	169.8	173.1	176.5	179.8	183.1	186.5	189.8	193.1	196.5	199.8	202.0
Actual	68.7	73.0	91.1	102.6	116.5	122.5	131.6	137.3	142.2	146.2	149.6	152.7	159.0	161.8	164.4	169.4	173.3	175.4	177.2			

Figure 3

(in Millions)											
	Thru 90	1Q91	2Q91	3Q91	4Q91	1Q92	2Q92	3Q92	4Q92	1Q93	2Q93
Forecast	148.435	6.205	3.334	3.334	3.335	3.334	3.334	3.334	3.335	3.334	3.334
Actual	132.688	4.107	3.373	3.121	5.521	3.659	2.603	4.967	3.402	2.721	1.979

	3Q93	4Q93	1Q94	To-date
	3.334	3.334	2.224	184.648
				168.141

Figure 4

Tidd PFBC Demonstration Plant
Quarterly Expenditures - DOE Share Phase III
Forecast versus Actual

(in Millions)		1Q91	2Q91	3Q91	4Q91	1Q92	2Q92	3Q92	4Q92	1Q93	2Q93	3Q93	4Q93	1Q94	To-date
Forecast		0.203	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.507	0.000	0.000	5.693
Actual		0.080	0.320	0.339	0.918	0.573	0.437	0.488	0.567	0.391	0.348				4.481

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