TIDD PFBC Demonstration Project

Quarterly Report

January 1994

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**

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, 175 Oak Ridge Turnpike, Oak Ridge, TN 37831; prices available at (615) 576-8401.

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161; phone orders accepted at (703) 487-4650.

This cover stock is 30% post-consumer waste
and 30% pre-consumer waste, and is recyclable.

DOE/MC/24132-3712

TIDD PFBC Demonstration Project

DOE

TIDD PFBC Demonstration Project

**Quarterly Report
October - December 1993**

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

**For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
P.O. Box 880
Morgantown, West Virginia 26507-0880**

**By
American Electric Power Service Corporation
1 Riverside Plaza
Columbus, Ohio 43215**

January 1994

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

TABLE OF CONTENTS

	PAGE
GLOSSARY OF ACRONYMS AND ABBREVIATIONS USED IN THIS REPORT	ii
I. INTRODUCTION AND SUMMARY	1
II. DESIGN AND PERMITTING	3
A. Engineering and Design Division	3
B. Environmental Engineering Division	9
C. Meetings	9
D. Testing	10
III. PROJECT SUPPORT	12
IV. TIDD PFBC PLANT OPERATIONS	13
A. Operations	13
B. Maintenance	23
V. MANPOWER REPORT	25
VI. COST DATA	27

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
CTF	Component Test Facility
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
GT	Gas Turbine

GLOSSARY OF ACRONYMS AND ABBREVIATIONS USED IN THIS REPORT

HPT	High Pressure Tubine
HVAC	Heating, Ventilating & Air Conditioning
I&C	Instrumentation & Control
IOI	Initial Operating Instructions
LPT	Low Pressure Turbine
MCR	Material Control Record
MCS	Management Command System
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 Instal
PTO	Permit to Operate
PWHT	Post Weld Heat Treatment

GLOSSARY OF ACRONYMS AND ABBREVIATIONS USED IN THIS REPORT

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 27th 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 October 1, 1993 to December 31, 1993.

Major activities during this period involve:

- The unit operated for 720 hours on coal.
- There were five gas turbine starts, five bed preheater starts, and three operating periods on coal fire.
- During the quarter, total gross generation was 36,672 MWH, the peak unit output for one hour was 64 MWH, and the coal consumption was 17,251 tons.
- Six performance tests were run during this quarter.
- The unit was tested with four sorbent feed points.
- The gas turbine low pressure compressor was disassembled to repair cracks in the stationary guide vanes.
- A request was sent to the DOE requesting funding for an additional year of operation.

Major items planned for the next period include:

- Continuation of sorbent utilization tests at various bed levels and sulfur retention values and with different coals and adsorbents.
- Operation at full load.

- Finalize the agreements with the DOE, Ohio Coal Development Office and technology suppliers for funding for an additional year of operation.

II. DESIGN AND PERMITTING

A. Engineering and Design Division

- Sorbent System

During this quarter, several modifications were made to the sorbent injection system in an attempt to improve sorbent utilization.

The sorbent injection system originally consisted of two 3 inch sch. 160 pipes, (2.624 inch ID) injecting sorbent into the bed between the No. 2 and No. 3 and the No. 4 and No. 5 fuel nozzles. Each nozzle extended approximately 6 inches into the bed.

The first modification this quarter consisted of installation of tees inside the fluid bed at the end of the sorbent lines. Each tee extended the sorbent line into the bed and to the centerline of the fuel nozzle skateboards. At the end of the pipe, a 3 x 2-½ x 2-½ inch reducing cross was installed in order to direct the sorbent flow under the skateboard. All the material used in this modification was 304L stainless steel.

The unit was started up in this configuration on October 16 and ran for 487:30 hours of coal fire operation. The unit was shutdown due to plugged primary cyclones. No connection could be found between the sorbent tees and pluggage of the cyclones. An inspection of the sorbent piping found severe erosion of the crosses and splitter plate. The most severe erosion was found adjacent to the splitter plate leading edge against the flow path. Sorbent impacted the splitter plate and then deflected into the sorbent pipe causing severe erosion of the sorbent pipe from the three to five o'clock and the seven to nine o'clock positions on the pipe cross section. The erosion was so severe that the pipe was almost cut in half. In addition, erosion was found in the dead leg and in the straight discharge lines after the 90 degree bend.

As a result of this erosion, a decision was made to install a new four point distribution system which split the sorbent into four pipes before it entered the fluid bed boiler. The unit was taken out of service on November 6 in order to install the new four point system.

The new system consisted of several tees and crosses that were designed to bifurcate the two sorbent existing pipes into four paths and then route these pipes directly into the bed parallel to the fuel nozzles.

Once each of the two original sorbent pipes penetrated the combustor vessel, the sorbent was directed through a series of two pipe tees which routed the sorbent line from parallel and to the side of the fuel nozzle to up and on top of the No. 2 and No. 5 fuel nozzles. From there, the sorbent pipe ran parallel to the fuel nozzle for 3 feet and then was split into two 2-½ inch sch. 160 pipes which had an ID of 1.771 inches.

The new 2-½ inch line sloped back down to the centerline of the fuel nozzles at which point it then changed direction again through a tee and was directed into the bed. Two new sorbent injection points were added, one on each side of the bed. The new points are located between the No. 6 fuel nozzle and the reinjection nozzle on the south side and the No. 1 fuel nozzle and reinjection nozzle on the north side of the bed. Once inside the bed, the nozzles ended approximately 6 inches inside the front wall of the boiler.

All of this temporary piping was stainless steel pipe intended to be used only as a test of this layout configuration. As such, the inner stainless pipe was jacketed at all the bends by a carbon steel outer pressure pipe which would aid in the detection of leaks in the inner pipe. The unit was started up in this configuration on November 24 and operated for a total of 230:16 hours before a leak was detected in the inner pipe. Upon inspection of the piping, severe erosion was found on several of the tee bends and crosses. The erosion was usually in the downstream side of the 90 degree bend, close to the bend corner.

The unit was then returned to two sorbent injection point operation until ceramic lined pipe could be obtained for this installation.

- **Secondary Ash Removal System**

As reported in earlier quarterly reports, the original secondary ash removal system was replaced in total during the Spring 1993 gas turbine outage. Since then, the system has operated very well with only two or three cases of ash line pluggage during operation. However, during the run starting on November 24, one of the 90 degree bends in the S24 secondary ash lines located outside the combustor developed a leak in service. These bends consist of an inner ash line pipe with an outer pipe jacketing all bends. The outer pipe has a test port drilled through it to test for leakage of the inner pipe. During this run, the inner pipe failed and leaked into the atmosphere through the test port. The ash line was shutdown in service via the isolation valve, the test port was capped, and the isolation valve reopened, thus putting the ash line back in service.

During the next outage, the bend was inspected and a very hard deposit was found in the bend. This deposit significantly increased velocities in the ash line and resulted in the line erosion.

- **Gas Turbine**

The gas turbine No. 1 and No. 2 bearings (LPC) experienced high vibration on October 18 as unit load was increased to 120 inch bed height. The vibration followed loading of the unit, limiting bed height due to alarm limits. Bed height was raised to 142 inches on October 27. The vibration decreased at the higher bed level and did not increase to previous levels when the load was decreased. An axial rub, due to ash in the LPT seals, is suspected to have caused the vibration problem.

The LPT blade roots were borescope inspected on December 8 after an accumulated 2211 hours of coal operation on the new blades. No indications were found.

The LPC first and second stage stationary guide vanes were borescope inspected from the LPC inlet on December 8. Cracks were found in the vane material in both stages. The LPC was dismantled and the guide vane rings were dye checked for cracks. The 1st stage had sixteen vanes cracked in the parent metal at the trailing edge inner sidewall. Many more vanes had extensive cracks in the brazing of the vanes to the inner and outer support rings. The 2nd stage had several cracked at the inner sidewall and one cracked loose at the outer sidewall. The third and fourth stage rings both had minor brazing cracks. The 4th stage also had a cracked inner ring. The ninth stage also had several major brazing cracks. Replacement 1, 2, 3, 4 and 9th stage guide vane rings were purchased from ABBC. The rings arrived on site on December 30. Reassembly of the LPC will be completed in the first quarter of 1994.

- **Fuel Splitting Air Configuration**

Due to excessive "egg" sinter formation experienced at high unit load, a decision was made to modify the fuel nozzle splitting air configuration. The modifications, which were installed during the outage at the end of 1993, included larger primary splitting air nozzles, slight retraction of those nozzles and the reintroduction of the secondary splitting air ring annular to the discharge nozzle. The changes to the primary splitting air nozzle are intended to achieve finer splitting of the fuel paste. The increase in the size of the air nozzle is intended to permit higher splitting air flows, whereas the retraction is intended to insure that the air nozzle discharge jet expands sufficiently to cover the entire fuel outlet nozzle area. The reintroduction of secondary splitting air, which was eliminated in the Fall 1991, is intended to eliminate dripping of large paste lumps that collect on the nozzle end cover plates. All of these changes are intended to eliminate large paste agglomerates, which are believed to be the initiators of the "egg" sinters. It is recognized that while improved fuel splitting may be helpful in regards to the sintering problem, it may exacerbate any post bed combustion problem. In addition to the above noted changes, the splitting air supply piping and valving is being modified to supply the secondary splitting air rings and to permit higher overall splitting air flow rates.

- **Sparge Ducts**

Problems experienced with the sparge duct assembly-to-assembly gap tiles during the previous quarter were eliminated through a redesign of the hold down clips. The ducts themselves, which were replaced during the Spring 1993 gas turbine outage, continue to function well with no signs of cracking or end distortion seen to date.

- **Post Bed Combustion**

During a series of runs in the final quarter of 1993, the unit was operated at full bed height of 142 inches, with little or no post bed combustion. This was evidenced by the mean cyclone inlet temperature running consistently within 10°F of the mean bed temperature. This was mainly accomplished through close operator attention to the consistency and moisture content of the coal paste.

- **Bed Sintering**

With the onset of cooler weather during the fourth quarter and the associated increase in gas turbine compressor air flow capacity, attempts were made to operate the unit at full bed height at the normal 1540°F mean bed temperature in order to obtain full load performance data. Operation at this high heat input condition resulted in excessive "egg" sinter formation, thus precluding continuous operation at that point. The interesting aspect in regards to the sintering is that it occurred with Pittsburgh No. 8 coal and Plum Run Greenfield dolomite sorbent. Periodic sintering had occurred before with these feedstocks; however, this had never been so significant as to affect continued operation, unlike the experience with Pittsburgh No. 8 coal and limestone (noted in the Third Quarter 1993 report). The sintering conditions noted could be mitigated by reducing bed temperature, increasing the fuel splitting air and increasing the coal paste moisture content. After recovering from one of these sintering events, the coal paste moisture was returned to normal and the bed temperature was increased in steps to determine the sintering threshold. This parametric testing revealed that operation at 1480°F was sustainable at 142-inch bed height, but temperatures over 1500°F resulted in

excessive sintering. Based upon the inability to operate the unit at full bed height with the normal 540°F bed temperature, a decision was made to revise the splitting air configuration. Additional sintering threshold testing is planned during the next quarter with the revised fuel splitting configuration.

The report from UNDEERC on their chemistry based investigation into the "egg" sinter problem was received. The investigation they performed was extremely thorough and the report provides a very probable explanation of the mechanisms behind the sinter formation as well as recommendations to mitigate the problem. A copy of this report will be submitted to the DOE separately.

- Sorbent Utilization

The freeboard SO₂ sampling system which became operational at the end of the last quarter was used extensively during this quarter to evaluate the freeboard SO₂ profile. Both SO₂ and O₂ measurements were taken. These measurements confirm the existence of high SO₂ and low O₂ concentration plumes at the fuel nozzle discharge regions. Data taken with the feed of fresh sorbent stopped for a period revealed high SO₂ concentrations directly above all three nozzles being measured (Nos. 1, 2 and 3). However, with the sorbent on, the concentrations measured above the No. 2 and 3 nozzles dropped dramatically, whereas the No. 1 nozzle concentration remained relatively high. This data reveals that the proximity of the fresh sorbent feed can dramatically reduce the plume SO₂ concentrations. Tests with biasing of the fuel pumps revealed that the high SO₂ concentration above the No. 1 nozzle could be reduced significantly by reducing the paste flow rate out of that pump. Sampling at the start of the next quarter will be directed at better determining the size of the fuel nozzle discharge plumes. This will be accomplished by concentrating the six sample point above one of the nozzles.

Performance tests were conducted with the tees installed on the ends of the original two sorbent feed nozzles. These nozzles were also extended into the bed resulting in direct feed of sorbent under each of the middle four fuel nozzle "skateboards." This change revealed no major sorbent utilization improvement.

As a result of the extremely high SO₂ concentrations identified above the No. 1 fuel nozzle, a four point sorbent feed configuration was designed and installed during this quarter. One performance test conducted with that configuration revealed a reduction in sorbent demand of approximately 15%. Prepared sorbent during that test was somewhat finer than normal, which may have played a role in the improved utilization. Additional testing is planned with the four point feed during the next quarter.

- **Sorbent Fines System**

The sorbent fines unloading and handling system, that was tested and performed satisfactorily, was further improved by modification to the sorbent fines silo feeder. In addition, a system was installed to feed prepared sorbent to the coal water paste. Also, a screw feeder was installed between the prepared sorbent silo and sorbent fines weigh feeder.

B. Environmental Engineering Division

- A cylinder gas audit was performed for the SO₂, CO₂, and NO_x monitors on December 29. All related accuracies were within acceptable ranges.
- The DOE's Environmental Monitoring Plan (EMP) requires quarterly reports be filed within sixty days of the quarter's end. In compliance with that requirement, the EMP Quarterly Report for the Third Quarter of 1993 was submitted to DOE in late November.
- Monitoring of solid, liquid, and gaseous waste streams, as required by the operations phase of the EMP, was performed throughout the quarter. Results of the monitoring will be included in the fourth EMP report due to DOE at the end of February 1994.
- All monthly and quarterly environmental monitoring reports were filed with the North Ohio Valley Air Authority and Ohio EPA, as required.

C. Meetings

- Tidd Performance Results Meeting

A two-day meeting was held at and near the Tidd site on December 15 and 16 to review and discuss unit performance results. The meetings were attended by various fluidized bed specialists from a number of outside organizations. The meetings focused primarily on understanding and improving the sorbent utilization and understanding and mitigating the "egg" sinter problem. A number of recommendations for both issues came out of these meetings. A copy of the notes from these meetings will be submitted separately.

D. Testing

The following performance tests were conducted during this quarter:

- Test 39: October 19, 1993: 115" Bed Level, 90% SR, 1480°F Bed Temperature
- Test 40: October 21, 1993: 115" Bed Level, 90% SR, 1540°F Bed Temperature
- Test 41: October 31, 1993: 115" Bed Level, 90% SR, 1540°F Bed Temperature
- Test 42: November 2, 1993: 142" Bed Level, 90% SR, 1540°F Bed Temperature
- Test 43: November 28, 1993: 115" Bed Level, 90% SR, 1540°F Bed Temperature
- Test 44: December 2, 1993: 142" Bed Level, 90% SR, 1480°F Bed Temperature

All tests were conducted utilizing Pittsburgh No. 8 coal and Plum Run Greenfield dolomite.

A summary of these test results is provided in Table 1.

TEST NUMBER			39	40	41	42	43	44
TEST DATE			10/19-20/93	10/21-22/93	10/31/93	11/02/93	11/28/93	12/02/93
OPERATING DATA								
n/a BED LEVEL (CALC)	INS		116.4	114.5	114.3	141.3	114.7	141.1
886 ST GEN MW	MW		38.0	41.5	41.0	45.6	42.2	42.1
885 GT GEN MW	MW		8.9	9.9	10.0	13.2	10.6	12.3
n/a COAL PASTE FLOW (CALC)	PPH		54917	59173	56818	60332	60358	63710
217 MEAN BED TEMP	F		1481.5	1540.0	1543.0	1539.5	1540.9	1480.0
691,692 INT VALVE INLET TEMP	F		1367.3	1392.3	1394.4	1514.9	1388.7	1468.5
191 AVERAGE BED OUTLET O2	%		5.3	4.3	4.7	3.7	5.1	4.9
260 MEAN CYCLONE INLET TEMP	F		1384.1	1415.2	1412.4	1534.3	1405.2	1485.2
604 AIR FLOW	KPPH		625.3	624.9	630.2	659.1	669.2	679.8
864 FEEDWATER FLOW (MVS)	KPPH		324.1	348.9	345.8	379.6	355.3	347.3
EMISSIONS								
710 SO2 LVG ESP (RAW)	PPM		220.1	207.1	190.9	192.5	177.4	90.3
709 NOX LVG ESP (RAW)	PPM		163.2	150.5	146.3	210.1	136.6	156.5
n/a NOX LVG ESP (CALC)	LB/MMBTU		0.29	0.25	0.25	0.33	0.24	0.27
n/a SO2 LVG ESP (CALC)	LB/MMBTU		0.58	0.52	0.49	0.46	0.47	0.25
FEEDSTOCK ANALYSIS								
SULFUR	WT. PCT. (D/B)		3.19	3.56	3.42	3.42	3.43	3.31
COAL SULFUR	LB S02/MMBTU		4.91	5.54	5.23	5.28	5.34	5.13
PASTE MOISTURE	WT. PCT. (A/F)		27.75	27.29	26.08	23.10	26.50	30.10
CALCULATED RESULTS								
FIRING RATE	MWT		151.4	162.1	161.0	176.4	167.2	168.5
SULFUR CAPTURE	PERCENT		88.1	90.6	90.6	91.2	91.1	95.1
CA/S TEST	----		2.62	2.49	2.29	2.14	2.30	2.82
CA/S @ 90%, 1580 TBED	----		2.30	2.24	2.07	1.86	2.02	1.75
CA/S @ 95%, 1580 TBED	----		2.99	2.91	2.69	2.42	2.63	2.27
COAL FLOW (DRY)	PPH (D/B)		39678	43025	42000	46396	44363	44531
TOTAL SORBENT FLOW	PPH		19950	22970	19660	20090	21150	24840
SORBENT IN PASTE	PERCENT		0.0	0.0	0.0	0.0	0.0	22.7

Table 1.

H:\WPRIWK\RESULTS.WG2

01/26/94

1

III. PROJECT SUPPORT

The plant personnel supervised and/or performed all construction activities during the quarter. Major Projects Division, however, continues to process significant purchase requisitions required to support the construction related work.

IV. TIDD PFBC PLANT OPERATIONS

A. Operations

The following is a summary of accumulated operating data for the period October 1, 1993 through December 31, 1993:

Steam Turbine Generation	29,196 MWH
Gas Turbine Generation	7,476 MWH
Total Gross Generation	36,672 MWH
Peak Generation for One Hour	64 MWH

Total Oil Fire Operating Time	20 Hours
Total Coal Fire Operating Time	720 Hours

Total Coal Injected	17,251 Tons
Total Sorbent Injected	16,472 KLB

The unit was operated for a total of 758 hours (including gas turbine air warming). There were five gas turbine starts, five bed preheater starts, and three operating periods with coal fire. The peak gross output of 64 MWH was for the period of 1100 - 1200 hours on November 29.

The Hot Gas Clean Up System was isolated from the system for the entire quarter.

1. Start-Up TD-SU-93-12-01 October 9 - October 10, 1993

The combustor was released to operations at 15:00 hours on October 9, 1993.

The unit was started for the purpose of testing the effects of multipoint (tees on existing two nozzles) sorbent injection into the bed.

The gas turbine was rolled at 06:15 hours, paralleled at 06:29 hours and the gas turbine valves opened at 06:36 hours on October 10.

When the sorbent booster compressor was placed in service, leaks were discovered on the sorbent injection piping flange gaskets near the boiler isolation valves.

The gas turbine was removed from service at 06:59 hours so repairs could be made to the piping on the sorbent injection lines.

While the repairs were made to the sorbent piping, boiler circulation was stopped and LCV-U200 was stroked and the bench set adjusted. (The valve had been leaking through.)

2. Start-Up TD-SU-93-12-02 October 10 - October 11, 1993

The combustor was released to operations at 14:20 hours on October 10 following the repairs to the sorbent injection piping.

The unit was started for the purpose of testing the effects of multipoint (tees on existing two nozzles) sorbent injection into the bed.

The gas turbine was rolled at 16:19 hours, paralleled at 16:35 hours and the gas turbine valves opened at 16:49 hours on October 10.

Oil fire was established at 21:36 hours and bed level was increased toward coal start bed of 26 inches.

All secondary cyclone dip legs except for No. 27 seemed to be plugged while warming on oil fire. (No. 23, 24, and 26 eventually opened as pressure vessel was pressure increased.)

The steam turbine was rolled at 00:31 hours and was paralleled at 01:21 hours on October 11.

Coal fire was initiated at 03:43 hours. Air flow was increased, freeboard mixing steam was placed in service, and sorbent injection was started with the east line at 04:41 hours.

Started to increase bed level at 05:20 hours but stopped the increase at 15:49 hours when No. 14 primary cyclone suction nozzle temperature started dropping, indicating that the dip leg was probably plugging.

The sorbent injection was removed from service at 06:04 hours and air flow increased to try to blow out the dip leg on No. 14 cyclone. The attempt was unsuccessful.

The combustor was tripped at 06:16 hours when No. 14 dip leg temperature started decreasing confirming that the dip leg was plugged.

All bed material was taken up into the bed ash reinjection vessel to be used for start-up bed material and the gas turbine was removed from service at 10:33 hours on October 11.

The combustor was continued to be cooled and then released to maintenance to work on cleaning out the cyclones.

3. Start-Up TD-SU-93-13-01 October 13 - 14, 1993

The combustor was released to operations at 16:50 hours on October 13.

The unit was started for the purpose of testing the effects of multipoint (tees on existing two nozzles) sorbent injection into the bed.

The gas turbine was rolled at 05:15 hours, paralleled at 05:32 hours and the gas turbine valves opened at 05:39 hours on October 14 and oil fire was established at 11:28 hours.

While all other cyclones showed signs of temperature increase following oil fire No. 14 cyclone did not, indicating that it was plugged. Air flow was increased to the speed/guide vane limit in an attempt to blow it clean. This attempt was unsuccessful.

The combustor was tripped at 13:44 hours. Following combustor cooling, the gas turbine was removed from service at 14:30 hours. The combustor was continued to be cooled and then released to maintenance for cyclone cleaning.

4. Start-Up TD-SU-93-14-01 October 16 - November 6, 1993

The combustor clearance was released by maintenance at 15:50 hours on October 16.

The unit was started for the purpose of testing the effects of multipoint (tees on existing two nozzles) sorbent injection into the bed.

The gas turbine was rolled at 01:16 hours, paralleled at 01:37 hours and the gas turbine valves opened at 01:41 hours on October 17.

Conservative measures were used to reduce the possibility of plugging cyclones. Process air to the bed bottom was not placed in service until coal fire and the purge air flow for sorbent injection was reduced until sorbent injection was required.

Oil fire was established at 08:38 hours, the steam turbine was rolled at 12:11 hours, and was paralleled at 13:27 hours on October 17.

Coal fire was initiated at 14:39 hours. Air flow was increased, freeboard mixing steam was placed in service and then sorbent injection was started at 16:03 hours. Bed temperature was held at 1480°F until the bed matured to evaluate sintering.

Bed level was increased and once through boiler operation was achieved at 00:41 hours on October 18.

Coal preparation system crusher skewing problems were encountered. It was determined that these problems were caused by a combination of moving the recycle screw discharge and machining of the crusher rolls. The recycle screw discharge was moved back to the original location and this improved the crusher performance to a condition that could sustain full load operation.

The gas turbine No. 2 horizontal vibration increased to approximately 190 mil/ sec. as air flow was increased. The LPC was cleaned using Carboblast in an attempt to reduce the vibration. The cleaning did not help the vibration and it remained higher than normal.

On October 21, conditions were established for a sorbent utilization test at 115-inch bed level, 1540°F bed temperature, 90% sulfur retention with Plum Run sorbent and the four point sorbent injection header.

On October 22, following the completion of the 90% sulfur retention test, conditions were established for another sorbent utilization test at the same conditions with 95% sulfur retention. These conditions could not be met because of excessively high sorbent injection flow requirements and bed ash removal not being able to remove enough bed ash to control bed level. This test was cancelled.

The sorbent fines admission system was test run on October 24 and placed in service with the paste system on October 25. A ratio of approximately 15% sorbent to coal was prepared. This ratio was maintained through 12:00 hours on October 29.

On October 26, the middle paste pumps fuel flow was biased up while the end paste pumps were biased down for bed temperatures and O₂ distribution. Sorbent utilization appeared to improve greatly. Bed level was increased to 141 inches on October 27. This was to evaluate the gas turbine LPC bearing vibration as well as to evaluate sorbent utilization.

The LPC vibration actually decreased during this activity.

On October 28, the fuel prep system crusher developed a problem with skewing again. The problem was encountered mostly when starting the system up. Bed level was reduced until the fuel prep crusher problems were overcome. By maneuvering the individual accumulator isolation valves, the crusher could be manipulated through the start-up sequence. After recycle was established, the isolation valve could be reopened.

On the evening of October 28, the sorbent preparation system cyclone separator plugged causing very hot air to pass through the bag house. The bags failed and required replacement.

Unit load was reduced to conserve sorbent until the bags could be replaced. Bed level was held at 120 inches while an inventory of sorbent could be prepared.

A sorbent utilization test was conducted at this bed level with 90% sulfur retention using 100% dry sorbent injection feed.

On November 1, bed level was increased to 142 inches for a 90% sulfur retention test. Bed level was held at 142 inches to let conditions stabilize.

The bed exhibited signs of sintering during the early morning hours of November 3. The test was aborted, bed temperature was reduced to 1500°F, the paste slump was increased (more water), sorbent feed was increased, and splitting air flow was increased. Bed material was also recirculated via the bed ash reinjection system to help break up the sinters.

By 08:00 hours on November 4, the bed conditions appeared to have recovered.

Conditions were then set for a 95% sulfur retention test at 142 inches on November 4, but the test was aborted Friday morning when the outlet duct opacity could not be maintained below 20% at the sorbent feed rate and low SO₂ level in the outlet gas stream. (The resistivity of the ash at low SO₂ levels makes it more difficult to collect.)

At approximately noon on Friday, November 5, prepared sorbent was started in with the paste at a 15% ratio of sorbent to coal.

At approximately 15:00 hours, the bed showed signs of sintering again. Bed temperature was decreased to 1500°F, the paste slump increased, dry sorbent feed rate increased, and prepared sorbent feed into the paste cut in half. Bed conditions leveled but did not drastically improve. At 20:30 hours, opacity increased to 20% because of the higher dry sorbent feed rate. Dry sorbent feed was decreased to maintain .35 to .40 lb/ MBtu SO₂. Bed conditions seemed to deteriorate further after this. Several evaporator tubes were in high temperature alarm and zone zero thermocouples still indicated the presence of sinters.

On the morning of Saturday, November 6, bed level was reduced to 115 inches in an attempt to stabilize the evaporator high and low temperatures (several tubes were below saturation temperature). Several bed parameters were maneuvered to try to raise the low evaporator tube temperatures. No improvement could be seen.

It was decided to remove the unit from service Saturday evening and inspect/ clean the tube bundle.

The Sands Hill test coal was crushed before shutdown with no visible ill effects.

The combustor was tripped at 22:09 hours on Saturday, November 6. The LPC was cleaned using Carboblast during the combustor cool down period and the gas turbine was removed from service at 02:20 hours on November 7.

The combustor clearance was released by maintenance at 19:53 hours on November 24.

The unit was started for the purpose of testing the effects of the new four point sorbent injection into the bed through the front wall and to perform full bed height tests (the tee arrangement inside the combustor instead of in the boiler proper).

The gas turbine was rolled at 00:50 hours, paralleled at 01:18 hours and the gas turbine valves opened at 01:33 hours on November 26. Carboblasting of the LPC was completed during the air warming time period.

Oil fire was established at 13:19 hours. The new purge air supply to the bed preheater needle valves from the splitting air precooler discharge was used for the first time. The purge worked well and the logic functioned as expected allowing the needle valves to remain open and purging during the run.

The steam turbine was rolled at 16:29 hours and was paralleled at 17:09 hours on November 26.

During the low air flow period before coal fire No. 24, 25, and 27 secondary cyclones were plugged but when air flow was increased after coal fire, they opened.

Coal fire was initiated at 18:00 hours. Air flow was increased, freeboard mixing steam was placed in service, and then sorbent injection was started at 19:12 hours.

Bed level was increased and once through boiler operation was achieved at 01:59 hours on November 27.

Bed level was raised to 115 inches and maintained there for the bed to mature. Following this, a performance test was conducted at 90% sulfur retention with only

dry sorbent injection (Plum Run No. 57) and Pittsburgh No. 8 coal. This test began at 20:00 hours on November 28 and lasted through 08:00 hours on November 29.

Problems were experienced with low splitting air flow on No. 1, 4, 5, and 6 paste lines. These were blown out with nitrogen and all were improved (No. 6 remained slightly lower for the remainder of the run).

Bed level was then increased to 142 inches with 1540°F bed temperature, 95% sulfur retention with Plum Run No. 57 sorbent, Pittsburgh No. 8 coal and sorbent fines with a ratio of approximately 15% sorbent to coal. These conditions were set for a performance test.

On November 29, a leak developed in the No. 24 secondary ash line long radius bend where it exits the building. The line was removed from service, a pipe plug installed in the outer piping, and the line returned to service.

On November 30, the bed had again reached a sintered state (bed temperatures in zone zero were dropping and unstable, several evaporator tubes were in high temperature alarm, and the bed density was decreasing). The test was aborted, bed level decreased to 115 inches, bed temperature dropped to 1500°F, and the sorbent fines system removed from service to purge the sintered bed.

On December 1, Peabody Anker coal was introduced into the fuel prep system. The finer size distribution of the incoming coal, combined with the moisture absorbed while it was stored in the coal pile, caused the throughput of the crusher to be limited to approximately 38 kpph. Because of this limitation, the switch was made back to Pittsburgh No. 8 coal.

Bed level was increased to 142 inches with bed temperature at 1480°F, 95% sulfur retention, Plum Run No. 57 dry sorbent feed and a 15% ratio of sorbent fines to coal as the paste.

A performance test was conducted at these conditions from 20:00 hours on December 2 to 1000 hours on December 3. (The sorbent fines system transport blower shaft broke, dictating the end of the fines admission testing at this time.)

After allowing the bed conditions to stabilize from removing the sorbent fines system from service, the bed temperature was increased to 1490°F at 08:00 hours on December 4. After seeing no ill effects of the bed temperature increase, the bed temperature was increased to 1500°F at 20:00 hours.

At 05:30 hours on December 5, the bed again exhibited the classic sintering symptoms (unstable and dropping bed temperatures in zone zero, high evaporator tube temperatures, and dropping bed density). Bed temperature was lowered to 1480°F and conditions allowed to improve. At 15:30 hours, the bed looked to be in a more stable condition and the bed temperature was increased to 1490°F.

By early morning of December 6, the bed again looked like sintering was occurring.

At 05:00 hours, the pressure indication of the sorbent injection header containment box on the north header began increasing and the sorbent dust was seen when blowing the pressure transmitter down. A leak had developed in the internal piping.

Because of the sorbent header leak, the combustor was tripped at 08:16 hours on December 6, 1993.

The bed material was cooled and the gas turbine removed from service at 12:50 hours on December 6, 1993.

The combustor was continued to be cooled and released to the maintenance department for outage activities.

B. Maintenance

1. Outage TD-OT-93-92 October 11 - October 13, 1993

Cleaned No. 13 and No. 14 primary cyclones, inspected all cyclones.

Machined rolls on coal preparation system crusher to remove unevenness.

2. Outage TD-OT-93-13 October 14 - October 16, 1993

Cleaned No. 14 primary cyclone ash line. Inspected all tee bends on No. 14 ash line.

Changed coarse filters on gas turbine low pressure compressor inlet.

3. Outage TD-OT-93-14 November 6 - November 24, 1993

Installed four-point sorbent injection system which is teed inside the combustor.

Installed alternate source of purge air to bed preheater from splitting air system.

Replaced sorbent air heater discharge duct.

Performed liquid cleaning of gas turbine low pressure compressor.

Made changes to test fuel nozzle assembly for fuel nozzle testing.

4. Outage TD-OT-93-15 December 6 - December January 8, 1994

Disassembled, repaired, and reassembled the gas turbine low pressure compressor due to cracks being found in the compressor guide vanes 1st, 2nd, 3rd, 4th, and 9th stages.

Modified fuel nozzles and splitting air piping to restore secondary splitting.

Enlarged the primary splitting air tubes and retracted 5 millimeters.

Removed four point sorbent injection piping and reinstalled two point piping pending the arrival of permanent ceramic lined four point injection piping.

Restored gas piping and support systems for returning HGCU back in service.

Installed new tempering air line for gas inlet to APF.

Spray coated the sorbent preparation system fan with Carbon 80 for erosion protection.

V. MANPOWER REPORT

As of December 31, 1993, American Electric Power Service Corporation actual work-hours for the Phase III accounted for 37.4% of the total budget of 135,098. Figure 1 represents the budget versus actual work-hours for this phase.

Figure 1.

VI. COST DATA

1. Project Cost Status

The actual cost shared expenditures during the Fourth Quarter 1993 were \$4,129,929 versus \$5,889,000 forecasted. As of December 31, 1993 the cumulative cost shared expenditures for Phase I, II, and III were \$175,016,186.

Figure 2 depicts the cumulative expenditure forecast for the project from Calendar Year (CY) 1988 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 Fourth Quarter 1993.

The following table summarizes the project expenditures as of December 31, 1993, of all participants:

	<u>DOE</u>	<u>QCDO</u>	<u>OPCO</u>	<u>Total Expended as of 12/31/93</u>
<u>Phase I</u> Design & Permitting	\$ 7,000,000	\$ 5,000,000	\$ 9,539,183	\$ 21,539,183
<u>Phase II</u> Construction & Start-up	\$47,000,000	\$ 5,000,000	\$ 70,223,888	\$122,223,888
<u>Phase III</u> Operation, Data Collection, Reporting & Disposition	<u>\$ 5,684,737</u>	<u>\$ 0</u>	<u>\$ 25,568,378</u>	<u>\$ 31,253,115</u>
Total:	\$59,684,737	\$10,000,000	\$105,331,449	\$175,016,186

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

2. Contracts Awarded During Fourth Quarter 1993

Major contractual commitments issued during this reporting period totalled \$620,395 and are summarized as follows:

<u>Purchase Order</u>	<u>Description (Contractor)</u>	<u>Contracted Costs</u>
C-7434	Revision No. 2 - Extension of Contract (Ecolochem - Pretreatment Cleanup Trailers)	\$241,000
C-7452	Revision No. 2 - Extension of Contract (Arrowhead Industrial - Condensate Cleanup Trailers)	\$144,000
07722-070-0	Extension of Contract (Tradet - Sampling and Chemical Analyses)	\$235,395

Figure 2.

\$ in Millions

	(in Millions)	1Q91	2Q91	3Q91	4Q91	1Q92	2Q92	3Q92	4Q92	1Q93	2Q93	3Q93	4Q93	1Q94	2Q94	To-date
	Thru 90															
Forecast	148,435	6,205	3,334	3,334	3,335	3,334	3,334	3,334	3,335	3,334	3,334	3,334	5,889	5,888	0,354	193,871
Actual	132,688	4,107	3,373	3,121	5,521	3,659	2,603	4,967	3,402	2,721	1,979	2,478	4,397			175,016

Figure 3.

	(in Millions)														
	1Q91	2Q91	3Q91	4Q91	1Q92	2Q92	3Q92	4Q92	1Q93	2Q93	3Q93	4Q93	1Q94	2Q94	To-date
Forecast	0.080	0.320	0.339	0.918	0.573	0.437	0.488	0.587	0.391	0.348	0.600	1.060	0.059	0.0	6.14
Actual	0.080	0.320	0.339	0.918	0.573	0.437	0.488	0.587	0.391	0.348	0.451	0.752			5.68

Figure 4.

DATE

FILMED

5/23/94

END