TIDD PFBC Demonstration Project

Quarterly Report
July 1 - September 30, 1993

October 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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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 Turbine
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 26th 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 July 1, 1993 to September 30, 1993.

Major activities during this period involve:

- The unit was restarted on June 29, 1993 and operated for a total of 1,288 hours on coal.
- There were eight gas turbine starts, seven bed preheater starts, and seven operating periods on coal fire.
- During the quarter, total gross generation was 44,666 MWH, the peak unit output for one hour was 58 MWH, and coal consumption was 22,635 tons.
- Gas turbine telemetry tests were accomplished during the first two runs of the quarter.
- The unit demonstrated the ability to achieve 95% sulfur retention at reduced bed levels.
- Sorbent utilization tests were conducted at various bed levels and sulfur retention values and with different adsorbents.

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.

II. DESIGN AND PERMITTING

A. Mechanical Engineering and Design Division

1. Engineering and Design

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

- Design and Permitting

Gas turbine LPT blade telemetry tests were conducted during the first two operation runs this quarter. The tests verified a reduction in the sixth nodal diameter, first mode blade resonant frequency vibration, from the modified blades. An operating curve was developed by ABB Stal, showing LPT inlet guide vane angle and LPT speed combinations to avoid during normal operation.

The unit was shut down on July 5 following completion of the telemetry testing to investigate the cause of high vibration instability at the No. 5 bearing. Vibration had reached levels of 450 mils/second during operation. Two of the five tilt pads in the No. 5 bearing were found with restricted movement and the HPC to reduction gear alignment was found out of design tolerances. The bearing was repaired and the unit realigned. Two LPT blades with strain gauges attached to the air foils were also removed during this outage.

Vibration at the No. 5 bearing following the unit's return to service was still high, limiting load to 100 inches bed level. A balance weight was installed at the HPC outlet on August 7. The gas turbine was rolled on August 8 and tripped from service on August 9 due to a false spike from the No. 1 bearing vibration instrumentation. The balance weights were rotated and the turbine

rerolled on August 10. Vibration levels were reduced significantly to below 200 mils/second at bed levels up to 128 inches.

The HPT experienced high disk temperatures on September 22. The adjustable V6 orifice that supplies seal/cooling air to the HPT disks was opened to reduce the disk temperature below the alarm point. Historical operating data since the Spring outage revealed that disk temperature was approximately 150°F higher than normal. The data indicates that the seal air passage the thermocouple penetrates is probably plugged and the thermocouple is reading disk temperatures instead of seal air temperatures. The thermocouple will be pulled and the ash will be blown out during the outage that began on September 24.

The gas turbine LPT blade roots were borescope and visually inspected on September 27 after an accumulated 1,295 hours of coal operation. No indications were found.

- Sintering with Limestone

In light of the excessive bed sintering that occurred in late August when using National Lime Co. Delaware limestone as the sorbent, a service order was issued to the University of North Dakota Energy and Environmental Research Center (UNDEERC) to perform a chemical characterization investigation of the cause of the sintering. They will analyze samples of coal, limestone, dolomite, and bed ash (with sinters from separate runs with dolomite and limestone) to attempt to determine why the sintering is so pervasive with the limestone as compared to the dolomite.

- Secondary Ash System

During this quarter, the unit was started up with the redesigned secondary ash system in service. This new system incorporated a

separate ash line for each secondary cyclone. The new lines were designed with a staged diameter starting at 3/4 inch diameter at the suction nozzle and increasing in diameter to 1-1/4 inches at the discharge into the economizer. Each ash line was designed to include a blowdown/blowback valve station to be used in case of pluggage in the ash line.

On the third start-up after the gas turbine outage, all six secondary cyclones were found to be plugged shortly after start-up. Once a coal fire was established and the pressure vessel pressure was significantly increased, the main ash line valve to the economizer was closed and the ash line was blown back into the cyclone dip leg. After several pulses back and forth, the ash line began to flow into the economizer once again. This type of back blowing has been used on several other occasions during the last quarter to unplug secondary ash lines in service after start-up.

In general, the new secondary ash line system has worked very well. Previously, the unit was usually operated with at least one secondary ash line plugged. However, since the new system has been placed in service, all ash lines have been operational in service with only minor pluggages occasionally occurring at start-up.

2. Phase III - Testing and Data Collection

- Unit Performance Testing

During this quarter, improved unit availability permitted twenty-two unit performance tests to be conducted. Many of these tests were a continuation of establishment of base line unit performance with Pittsburgh No. 8 coal and Plum Run Greenfield dolomite. In order to properly verify this base line, tests have been run at varying bed heights and varying sulfur retention levels. The extent of this testing exceeds what was identified in the "Detailed Test Plan." It

was determined that this more thorough base line testing was necessary in order to properly evaluate the impact of planned changes in coal, sorbent, sorbent sizing and feed method, and sorbent distribution. Additional full load data is still needed to complete the base line testing, and this is planned for collection during the next quarter when cooler ambient temperatures should permit high load operation. In addition to the base line testing, two alternate dolomites, a higher sulfur batch of Pittsburgh No. 8 coal, fine sorbent fed with the coal paste, and a wetter coal paste were tested. The following is a listing of the performance tests conducted this quarter:

BED		SULFUR			REMARKS
<u>DATE</u>	<u>HEIGHT</u>	<u>COAL</u>	<u>SORBENT</u>	<u>RETENTION</u>	
7/22	95"	Pit No.8	P.R. Gr.	90%	Higher 6 lb. SO ₂ coal versus normal 4.5 lb.
7/23	80"	Pit No.8	P.R. Gr.	90%	
7/26	80"	Pit No.8	P.R. Gr.	90%	
7/27	80"	Pit No.8	P.R. Gr.	90%	
7/28	80"	Pit No.8	P.R. Gr.	95%	
7/29	80"	Pit No. 8	P.R. Gr.	95%	
7/31	80"	Pit No.8	P.R. Gr.	95%	
8/4	80"	Pit No. 8	P.R. Gr.	85%	Wetter than normal coal paste
8/5	80"	Pit No. 8	P.R. Gr.	85%	
8/13	115"	Pit No. 8	P.R. Gr.	90%	
8/14	115"	Pit No. 8	P.R. Gr.	90%	
8/21	115"	Pit No. 8	P.R. Gr.	95%	
8/22	115"	Pit No. 8	P.R. Gr.	95%	
8/23	115"	Pit No. 8	P.R. Gr.	90%	

<u>DATE</u>	<u>BED HEIGHT</u>	<u>COAL</u>	<u>SORBENT</u>	<u>SULFUR RETENTION</u>	<u>REMARKS</u>
9/2	115"	Pit No. 8	P.R. Gr.	90%	Approx. 50% of sorbent fed with paste.
9/4	80"	Pit No. 8	P.R. Gr.	90%	SAME AS ABOVE
9/11	115"	Pit No. 8	P.R. Gr.	85%	
9/13	80"	Pit No. 8	P.R. Peeb.	90%	
9/14	80"	Pit No. 8	P.R. Peeb.	95%	
9/16	80"	Pit No. 8	N.L. Carey	90%	
9/17	80"	Pit No. 8	N.L. Carey	95%	
9/23	125"	Pit No. 8	P.R. Gr.	90%	

P.R. Gr. = Plum Run Greenfield dolomite
 P.R. Peeb. = Plum Run Peebles dolomite
 N.L. Carey = National Lime Carey dolomite
 Pit No. 8 = M&M Betsy Mine Pittsburgh No. 8 coal

Unit Operation and Testing

In the thirteen-week period following the Spring 1993 outage, Tidd has fired coal for a total of 1,271 operating hours with a longest continuous run of 597 hours. During this period, twenty-two unit performance tests were conducted, of which fifteen were for establishment of base line performance including testing at 95% sulfur retention, two were for evaluation of feeding fine sorbent in with the coal paste, and four were for evaluation of two additional dolomites. In addition, a test was attempted with limestone as the sorbent. However, this resulted in a shutdown due to excessive sintering in the bed, thus revealing potential sorbent selection

problems. Key base line unit performance data with Pittsburgh No. 8 coal and pneumatically fed -6 mesh Plum Run Greenfield dolomite are summarized as follows:

<u>BED HEIGHT</u>	<u>%FIRING RATE</u>	<u>CA/S RATIO AT 1580°F BED TEMPERATURE</u>		<u>NOx</u>
		<u>90% RET.</u>	<u>95% RET.</u>	
80"	53%	2.5	3.3	.19ppmbtu
115"	78%	2.3	3.1	.22ppmbtu

- Key Equipment Issues

The gas turbine (GT), which underwent extensive repair during the Spring, initially required some iterations at balancing; however, once balanced, it operated without incidence. Boroscope and visual inspection after this operating period revealed no signs of LPT blade root cracks and an insignificant amount of erosion at the LPT inlet guide vanes.

The secondary ash removal system, which was extensively modified to six individual transport lines during the Spring 1993 outage, has functioned extremely well with minimal incidents of plugging. Even when plugs occurred, the provisions incorporated into the design to permit unplugging on line were fully effective.

The replacement sparge ducts, which were fabricated at a Columbus, Ohio fabrication shop at a significant cost advantage over the OEM supplier, have functioned as expected with no major problems.

3. Performance Test Results

System/ Equipment Issues

- Boiler Air/ Gas Side
Sparge Ducts

The new sparge duct arms, which were installed during the Spring 1993 gas turbine outage, have functioned well with no signs of cracking or other stress to date. The only problem experienced with the new installation has been that a couple of the sparge duct slip joint cover tiles have come loose. The particular tiles that have experienced the problem were part of a new design for the assembly-to-assembly gap tiles. Methods to better secure these tiles are presently being investigated.

A particularly interesting aspect of the new sparge duct design was the elimination of the passive end fluidization pipes and their replacement with an active end fluidization system. The duct ends must be fluidized during bed preheating to avoid ash compaction and compressive loading on the ducts as they grow thermally during bed preheating. Insufficient fluidization from the passive end fluidization pipes, which just distributed a fixed portion of the overall fluidization air to the duct ends, was originally thought to be the cause of the duct bending that necessitated their replacement. However, investigation of the fluidization condition at the duct ends showed that this area had a significantly higher proportion of fluidizing air per unit area than the rest of the bed and, hence, this region was probably over fluidized and may have remained so throughout the unit operation. This would have likely resulted in very high temperatures out at the ends of the ducts perhaps in excess of the bed temperature. How such a situation could have been conducive to the bending of the ducts is not understood;

however, signs of such a hot fluidized region were evident in agglomerated bed ash masses that would typically be found in these regions after unit shutdowns. The new design has no passive end pipes but relies on an active end fluidization system which uses higher pressure sorbent air to fluidize the duct end regions periodically during bed preheating. Operation with this new arrangement has resulted in the elimination of the agglomerated masses at the duct ends. In addition, duct end deflection monitoring tabs installed on two of the sparge duct assemblies have shown no signs of excessive end loading.

Post-Bed Combustion

Post-bed combustion is still present in varying degrees, depending on the consistency of the coal water paste. Variations in the mean cyclone inlet temperature have been typically as high as +80°F (1420 - 1500°F) at 115-inch bed height. Operation at approximately 125-inch bed height on September 23 resulted in the HPT exhaust temperature in high alarm. The coal paste on that particular day exhibited a 4-inch slump, which is only slightly wetter than the desired condition (3 - 3.5 inches in a concrete slump test). In order to achieve maintainable full load without exceeding the allowable GT HPT inlet and/or outlet temperatures, the coal paste will need to be dried up as much as the coal pumpability will permit. There is an extremely fine balance here.

- Bed Preheater

Lighting

In addition to the temporary problem with the piping arrangement, the bed preheater has been difficult to light on numerous occasions. Inspection of the burner heads, flame tubes, and lighters has not revealed the cause of the problem. Investigations of this matter will continue.

- Coal Preparation System
Coal Crusher

The crusher continues to exhibit roller skewing problems when started up. This is usually combatted by manual roller engagement and by allowing the crusher to run continuously, even when there is no material throughput.

Testing of a 150 ton batch of Peabody coal revealed no major problems with crushing that coal. As such, this coal can be considered in future testing of the unit. This batch testing mode was incorporated into the unit test program to identify whether crushing problems would be likely with potential candidate test coals. This was done in order to avoid unusual crushing problems such as the insufficient crusher capacity problem experienced with the Ohio No. 6A coal in late 1992 and early 1993.

Coal Chutes

The chutes in the coal preparation system were fabricated from fairly light gauge steel. During the runs discussed herein, there were numerous instances where the chutes had eroded clear through. The chutes are presently being repaired with heavier gauge steel and erosion resistant linings are being installed where deemed necessary.

- Coal Injection System
Injection Nozzles

The unit experienced only one on-line nozzle plug during the period noted herein. The incidence of plugging has been dramatically reduced mainly due to proper paste preparation.

The coal nozzle inserts exhibited minimal wear during this operating period; however, there was still some minor heat checking and erosion. The change to RA 333 high nickel alloy material has dramatically extended the life of these components.

Injection Pumps

Local control panel problems caused a unit trip on August 14 due to a falsely low flow feedback. The NET 90 control logic has been modified to protect against such an event.

Additional local control panel problems have caused a number of instances where individual pumps have not started on initiation of coal injection. Such an event occurred on the August 29 unit start up, and coal fire was then initiated on just five pumps, which is the first instance with less than all six pumps. The malfunctioning pump (No. 3) was eventually brought back on line.

Upon inspection after the September 23 trip of the unit, thick deposits of dried coal paste were found in the pump suction boxes, as well as in the paste tank. The deposits were much thicker than was ever noticed before. The mixing of sorbent fines with the coal paste is suspected as the cause.

Splitting Air Compressor

As a result of the modified fuel nozzle design installed during the Fall 1991 outage, the splitting air flow demand decreased dramatically. This situation resulted in the splitting air compressor being oversized, which necessitated excessive throttling on the suction to achieve the desired lower flow rates. This, in turn, imposed extremely high pressure ratios on the reciprocating compressor resulting in excessive discharge temperatures. This situation was resolved by installing a temporary recirculation line

(hose) back to the suction of the sorbent air compressor. While this resolved the problem, it resulted in dramatically increased frequency of fouling of the fine sorbent compressor inlet filter. A more permanent and less troublesome solution to this problem was undertaken during the Spring 1993 outage. During that outage, new sheaves were installed on the compressor to reduce its operating speed and, hence, its capacity. This then permitted elimination of the temporary recirculation line. This modification proved successful during the operating period noted herein; however, the base mounting springs had to be defeated by fixed plates to minimize resonant vibrations at the new reduced operating speed.

Valves

The lockhopper depressurization valves experienced excessive leak through on the last run of this period, which necessitated the use of manual isolation valves in series with the leaking valves.

Leaking of these valves is suspected as the cause of the inadvertent bed ash draining episodes that occurred on preceding runs. It is theorized that with leaking vent valves, the lockhoppers will be at a reduced pressure relative to the bed, thus inducing bed ash drain flow through the L-valve even when there is no fluidizing air.

- Bed Ash Reinjection

- L-Valves

During runs prior to the Spring 1993 GT outage, as well as during one run since then, plugs were experienced in the reinjection vessel discharge L-valves. This periodic problem is ongoing and is still under investigation.

- Sorbent Preparation
Crusher

A short test of increased crusher speed on August 30 revealed that increased system capacity and increased product fineness (finer coarse material without increased -60 mesh readily elutriated "fines") could be obtained at the higher speed. An attempt to duplicate this performance some three weeks later in the run was unsuccessful. It is believed that this operating inconsistency was due to normal wear of the crusher. The increased capacity is needed to support high load operation reliably, and the increased fineness is desired due to potential for improved sorbent utilization.

Screen

The screen in this system continues to be a maintenance problem. Failures at the wire to frame interface have been occurring on about a weekly basis. It is suspected that the screen fails due to buildup of material that occurs at high throughput. Such high throughput is needed to maintain the supply of sorbent to the unit at the higher loads and/or increased sulfur retention levels; however, the capacity is well below the original design capacity for the system. The plant is investigating the potential purchase of a higher capacity screen.

4. Detailed Investigations
 - Sintering with Limestone

The bed sintering event with limestone that occurred in August is the third instance where this has occurred when using the National Lime Delaware limestone. The previous two events occurred in the Fall of 1992. Since both of those occurrences happened on unit

start-ups, it was decided that a third try should be attempted after successfully starting the unit on dolomite. The intent of this latest try was to rule out any start-up phenomenon (i.e. sand used in the start bed) as a possible contributor to the sintering. Given the results, we now know that the limestone is the culprit; however, we do not understand the cause. In an attempt to determine the causative effect, we initiated discussions with the University of North Dakota Energy and Environmental Research Center (UNDEERC) to determine if they could help us in this matter. As a result of these discussions, we have not issued a service order to UNDEERC to perform a chemical characterization investigation of the cause of the sintering. They will analyze samples of the Plum Run Greenfield dolomite, National Lime Delaware limestone, bed ash with sinters from separate runs with the limestone and dolomite, and the Pittsburgh No. 8 coal. By mainly looking at the mineral and elemental compositions of these materials, as well as the morphology (structure of the bed ash and egg sinters), they will attempt to determine the mechanism of the sinter formation focusing on the differences between the limestone and dolomite. The results of this analytical investigation are expected in early November.

UNDEERC has also indicated that they have a 3-inch diameter bench scale PFBC rig which they can set up to perform ash agglomeration experiments for us. Depending on the outcome of the analytical investigation, we may pursue this experimental approach if it appears worthwhile.

- Sorbent Utilization

The sorbent utilization performance is worse than the original design curve predicted from ABB Carbon's experience at their 15 MW PFBC Component Test Facility (CTF). In order to minimize the cost of a commercial PFBC facility, it will likely be necessary

to not only meet that design curve but further improve on it. As such, various methods have been discussed as possible ways to improve the sorbent utilization in order to lower the sorbent demand as well as the ash generation.

The first suggestion from ABB Carbon (ABBC) for improving sorbent utilization was to feed the sorbent with the coal paste. It was theorized that by feeding in this manner, the -60 mesh fines, which are readily elutriated, would stick to the split coal paste lumps and thus be better spread out as the paste lumps move around with the churning bed. They noted that with the two point pneumatic feed, the fines were concentrated in a finite region, causing SO₂ depletion in that region and thereby resulting in underutilization of the sorbent fines. The sorbent fines admission system was then conceived based upon this theory. The design basis of that system was to feed approximately 50% of the sorbent as -60 mesh fines, with the remainder fed pneumatically as -6, +60 mesh material. The eventual intent was to separate out the fines from the normal sorbent preparation system in an additional screening process and transport them to the sorbent fines admission system for mixing with the coal paste. In order to verify that sorbent could be added to the coal paste and fed to the bed with no adverse effects, three rough performance tests with sorbent in the paste were performed in August 1992. These were accomplished by means of temporary variable speed screw feeders. In two of the tests, the normal -6 mesh material was fed with the coal paste: one with approximately 50% in the paste and 50% pneumatically and the other with 100% fed with the paste. The third test involved feeding approximately 50% of the sorbent as fine material (100% < 16 mesh, 58% < 400 mesh) with the paste. These tests confirmed that sorbent could be fed with the coal paste with no adverse effects on pumpability or fluid bed. However, they indicated that the sorbent utilization was somewhat reduced when feeding in this manner. These results, admittedly rough, were then reviewed

with ABBC. At that point, ABBC revised their theory somewhat. They now suggested that the sorbent be fed with the paste but after being crushed as fine as possible, preferably as small as 10 microns (approximately 1300 mesh), to increase its effective surface area. They theorized that the small particles would agglomerate into larger particles for a period of time and thus remain in the bed long enough to be highly utilized. While this latter theory was recognized as unproven, it was also recognized that in order to perform such testing in a proper manner, the permanent sorbent fines admission system would be needed.

Based on this and the output from the rough testing that showed no problems when feeding sorbent with the paste, work proceeded on the permanent system. The recent tests performed in September 1993 involved feeding approximately 40% of the sorbent as fine material with the coal paste while the remainder was fed pneumatically as the normal -6 mesh size prepared material. The fine material was the same Plum Run Greenfield dolomite as the coarse; however, it was crushed at a nearby limestone supplier to a very fine product (100% < 200 mesh, 35% < 1300 mesh, 10 microns). These tests showed an approximate 10% improvement in sorbent utilization; however, more testing is needed to verify these results.

The above noted theory assumes that the SO_2 is evenly spread across the bed area. Late in 1992, ABBC proposed a new theory that the SO_2 is not evenly distributed but is very high in the regions near the fuel discharge points. They postulated that a large portion of the sulfur is released with the volatiles and hence is released local to the fuel nozzles, since devolatilization is rather rapid. They referenced the existence of the O_2 depleted plume regions as evidence of the localized volatile release. ABBC proposed that if such a locally high concentration existed, then it would be more appropriate to feed the sorbent pneumatically into

these regions where the fines could then be best used. They noted that feeding with the paste may not be that beneficial, since the fines would likely stay with the devolatilized char and move to other regions of the bed before sulfating. Recognizing that we had already validated the existence of the volatile plumes at Tidd, we felt that if a large amount of sulfur is indeed released with the volatiles, then ABBC's SO₂ plume theory might be valid. As such, we had Tra-Det Inc. run a volatile matter test on two coals we had been using at Tidd (Pittsburgh No. 8 and Ohio No. 6A) in accordance with ASTM procedure D3175 while measuring the sulfur concentrations both before and after the test. These tests showed that for both of the coals tested, over half of the sulfur was released with the volatiles, thus providing some credence to ABBC's new theory. In order to further validate this theory, we determined that if such high concentration plumes exist, they should be readily measurable just above the bed. With this in mind, an SO₂ analyzer was purchased and the former freeboard O₂ sample system was converted to measure SO₂ in both the plume and non-plume regions of the bed. This new system became fully functional for the first time late in the last run discussed in this report. Readings taken along the centerline of the No. 1 fuel nozzle on September 23 were as follows:

Directly above the center of the "skateboard"	2600 - 2800ppmv
Half way from the front wall to the "skateboard"	190 - 450ppmv
Half way from the rear wall to the "skateboard"	350 - 600ppmv
	with spikes to
	1100

With the bulk flue gas SO₂ concentration running approximately 230ppmv, this limited data appears to validate the SO₂ plume theory. Additional and more comprehensive data will be taken on future runs.

In relation to the above discussion, a four-point sorbent distribution system was installed in the outage following the run that ended on September 23. This revision extends the existing two sorbent feed lines further into the bed and uses tees to distribute the sorbent under the "skateboards" i.e. the inner four coal nozzles. In addition to this modification, the sorbent crusher was rebuilt in the same outage. With the rebuild and the use of the high speed drive sheaves, the prepared sorbent should be finer. Performance and freeboard SO₂ data from the following run should allow determination as to whether the combined effect of these changes improves sorbent utilization. If the results are positive, additional testing will be necessary to determine the relative merit of the two alterations. In regard to the sorbent distribution tees, it is recognized that the design is temporary in that the lines will likely erode at or near the tees within a week or so. This is mainly due to the fact that the splitting tees are located inside the bed, thus precluding the use of erosion resistant but bulky ceramic linings. Given the possibility that improved distribution of the sorbent may improve sorbent utilization, the design of a permanent four-point distribution system is presently being investigated.

- Sorbent Reactivity

As determined in pilot plant investigations and verified in the alternate dolomite testing performed in September, the relative reactivity of the sorbent impacts its utilization. In future commercial plant investigations, a useful means to determine the reactivity of candidate sorbents will be needed in order to properly evaluate the plant economics as well as the sorbent preparation system, sorbent injection system, and bed ash removal system capacity requirements. One potential test is the Pressurized Thermogravimetric Analysis (PTGA), which measures the weight change versus time of a small sample of sorbent exposed to sulfur laden gas under pressure (approximating the PFBC flue gas

conditions). In order to determine whether such a test is valid, we have issued a service order to UNDEERC to perform PTGAs on nine samples of sorbent which include four dolomites (near equal molar quantities of Ca and Mg), three limestones (very low amounts of Mg), and two dolomitic limestones (appreciable Mg but much lower than Ca). Three of the dolomites are the ones tested so far at Tidd. The relative results from the PTGA testing for those three dolomites will be compared to the results from the testing at Tidd to determine the PTGA test's usefulness. If a positive correlation is found, additional tests may be run on some of the other six stones that PTGAs were performed on. Results from the PTGA testing are expected by the middle of October.

B. Electrical/ Controls Engineering and Design Division

- Assisted plant personnel in daily operations and developed applications as requested by Mechanical Engineering and Design Division.

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 second quarter of 1993 was submitted to DOE. Because the PFBC unit was inoperative throughout the second quarter, the EMP for that period covered only the PFBC ash disposal area groundwater monitoring results.
- 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 third quarter EMP report due to the DOE at the end of November 1993.

D. Civil Engineering and Design Division

- The sorbent fines unloading and handling system was tested on September 1 and September 2. The system performed satisfactorily, met the design parameters, and was turned over to Operations.
- We are working with Smoot Co., the supplier of the above-referenced system, to release retention and other final payments.

III. MAJOR PROJECTS DIVISION

No major construction activities were performed this period. However, Babcock & Wilcox Construction Company demobilized from the job site at the end of June following completion of installation of the new sparge duct assemblies.

IV. TIDD PFBC PLANT OPERATIONS

A. Operations

The following is a summary of accumulated operating data for the period July 1 through September 30:

Steam Turbine Generation	38,204 MWH
Gas Turbine Generation	6,462 MWH
Total Gross Generation	44,666 MWH
Peak Generation for One Hour	58 MWH
Total Oil Fire Operating Time	39 Hours
Total Coal Fire Operating Time	1288 Hours
Total Coal Injected	22635 Tons
Total Sorbent Injected	11370 Tons

The unit was operated for a total of 1,399 hours (including gas turbine air warming). There were eight gas turbine starts, seven bed preheater starts, and seven operating periods with coal fire. The peak gross output of 58 MWH was for the period of 11:00 - 12:00 hours on September 23.

The unit was in service at the beginning of the quarter. Test data was being collected from the temporary strain gauges on the gas turbine LPT to evaluate the new blades.

Following this testing, bed level was lowered to 80 inches and the combustor tripped at 05:05 hours on July 3. The gas turbine was removed from service at 09:48 hours following the cooldown period.

The Hot Gas Clean Up System (HGCU) was attached to the system for the entire quarter.

1. Start-Up TD-SU-93-05-01 July 4 - July 5, 1993

The purpose of the run was to obtain additional strain gauge data from the gas turbine LPT blades.

The combustor gas side had been bottled up and temperatures were maintained well above dew point while the wiring and batteries were changed on the gas turbine strain gauge telemetering.

The gas turbine was rolled at 17:10 hours, paralleled at 17:34 hours, and the valves opened and air flow established through the combustor and APF at 17:42 hours on July 4.

An oil fire was established at 19:39 hours, the steam turbine was rolled at 21:43 hours, and paralleled at 22:34 hours, and at 00:35 hours on July 5, a coal fire was established.

Air flow was increased to meet conditions for the first set of LPT blade strain gauge testing.

Following the first set of tests, the bed level was increased to match inlet guide vane conditions for more testing of the LPT blades.

Once through boiler operation was accomplished at 07:56 hours.

Several series of strain gauge tests were accomplished at varying air flows and inlet guide vane positions.

Following the completion of all of the planned LPT blade strain gauge testing, bed level was reduced using the bed ash removal system and the combustor was tripped at 17:17 hours on July 5. (This outage was to replace the temporary strain gauge blades with permanent blades.)

The combustor and APF were cooled with gas turbine air flow and the gas turbine removed from service at 22:16 hours. Cooling of combustor and APF continued with the combustor cooling fan in preparation for maintenance outage work.

2. Start-Up TD-SU-93-06-01 July 17 - August 5, 1993

The unit was released by the maintenance department at 16:25 hours on July 16.

The purpose of the run was to conduct sorbent utilization tests at various bed levels and sulfur retention values.

Gas recirculation was started at 23:30 hours. Warming of the APF was accomplished by flowing dry air up through the screw cooler into and through the filter vessel.

When starting the HGCU backpulse compressor, the fourth stage would not load. The backup compressors were used while the backpulse compressor was repaired.

The gas turbine was rolled at 17:01 hours on July 17. The gas turbine was removed from service because of a problem with leaks on the heads of the splitting air compressor.

The gas turbine was rolled again at 23:25 hours and paralleled at 23:49 hours. The valves were opened and air flow established through the combustor and APF at 00:01 hours on July 18. The warming of the combustor was accomplished while using sorbent booster compressor air for splitting air while the splitting air compressor was being repaired.

The splitting air compressor was returned to service at 08:05 hours.

An oil fire was established at 10:53 hours.

The backpulse compressor was returned to service at 12:31 hours.

The steam turbine was rolled at 14:39 hours and paralleled at 15:28 hours and at 18:20 hours, a coal fire was established.

All the secondary cyclone ash outlet pickup pots were plugged and required blowing back through the external blow-back piping from the sorbent air system. All opened up and remained open for the remainder of the run.

Bed level was raised to 45 inches and maintained there to build bed material inventory. After accomplishing this, the bed level was increased and once through boiler operation achieved at 08:25 hours on July 19.

Load was increased to approximately 110-inch bed level. The gas turbine No. 5 bearing vertical vibration increased into alarm as load was increased on the gas turbine generator. The alarm point was raised to 350 mils/second, and unit operation was limited in order not to exceed this point for the rest of the run (bed level was eventually lowered to 80 inches to avoid alarm conditions). Several operating adjustments were made to try to determine the cause of the vibration.

Sorbent utilization tests were done at 95-inch bed level with 90% sulfur retention, 80-inch bed level with 90% sulfur retention, and 80-inch bed level with 95% sulfur retention.

A sorbent utilization test at 90-inch bed level with 85% sulfur retention was completed on August 4.

A manual trip of the combustor was initiated at 12:22 hours on August 5 because of a high level of ash in the APF, after all efforts to remove the ash and clear the alarm were unsuccessful. The gas turbine was removed from service at 15:33 hours.

3. Start-Up TD-SU-93-07-01 August 8 - August 9, 1993

The unit was released by the Maintenance Department at 16:37 hours on August 8.

The purpose of the run was to continue to conduct sorbent utilization tests at various bed levels and sulfur retention values.

The gas turbine was rolled at 20:52 hours, paralleled at 21:07 hours, and the gas turbine valves opened at 21:24 hours.

During gas turbine air heating, the LPC No. 1 vertical vibration became erratic. Connections were checked and tightened. This seemed to stabilize the indication. The LPC was cleaned using Carboblast during the air heating period.

The bed preheater was lit at 03:43 hours on August 9. The steam turbine was rolled at 05:55 hours and the steam turbine generator was paralleled at 06:49 hours.

A coal fire was attempted at 08:23 hours but was ordered back off when No. 1 and No. 3 paste pumps did not start. The pumps were put in recirculation and a successful coal fire established at 10:18 hours.

Sorbent injection was initiated at 11:10 hours.

While increasing air flow, the No. 5 HPC bearing vertical vibration increased as it had on the previous run.

At 11:38 hours on August 9, the gas turbine tripped when the No. 1 LPC bearing vibration spiked high while the No. 5 HPC vertical vibration was in high alarm.

The gas turbine was cooled on barring and prepared for a balance shot.

4. Start-Up TD-SU-93-08-01 August 10 - August 14, 1993

The gas turbine was released by the Maintenance Department at 13:21 hours on August 10.

The purpose of the run was to continue sorbent utilization tests at various bed levels and sulfur retention values and evaluate the gas turbine balance shot.

The gas turbine was rolled at 15:21 hours, paralleled at 15:36 hours, and the gas turbine valves opened at 15:53 hours.

The bed preheater was lit at 16:23 hours.

The steam turbine was rolled at 18:50 hours, but problems were experienced when trying to parallel.

A coal fire was established at 22:29 hours.

A loose connection was found on the yard running potential for the steam turbine generator synchronizing circuit and the generator was paralleled at 23:01 hours.

Sorbent injection was initiated at 23:14 hours.

Once through operation of the boiler was achieved at 08:14 hours on August 11.

During the evening of August 12, bed level was raised to approximately 125 inches with air flow of 680 kpph. The air flow was limited at this time by the capacity of the gas turbine intercooler. At this air flow and bed level, the vibration indication was approximately 200 mil/second. The

balance shot had helped significantly.

Bed level was reduced to 115 inches and the unit operated with sorbent injection overfeed to accumulate sulfur retention credits for the upcoming 85% sulfur retention test.

A combustor trip was experienced at 05:27 hours on August 14 when the No. 5 paste pump controls caused the pump to go to a very high pumping rate while flow feedback to the NET 90 system failed low.

The bed level was reduced to start bed level and a hot restart was attempted. Attempts at lighting the bed preheater were unsuccessful for unknown reasons.

The gas turbine was removed from service at 12:11 hours to permit working on the bed preheater and on the No. 5 paste nozzle which was plugged.

5. Start-Up TD-SU-93-09-01 August 14 - August 15, 1993

Following the checks on the bed preheater (which did not reveal any problems) and the unplugging No. 5 fuel nozzle, the combustor was released at 20:00 hours on August 14.

The gas turbine was rolled at 22:05 hours, paralleled at 22:22 hours, and the gas turbine valves opened at 22:34 hours.

The bed preheater was lit at 23:18 hours.

Following oil fire, No. 13, No. 14, and No. 15 primary cyclones appeared to be plugged. Air flow was raised as much as possible in an attempt to blow out the plug. No. 13 and No. 14 unplugged but No. 15 did not. When No. 25 showed signs of carrying over from the primary, the combustor was tripped at 02:14 hours on August 15.

The combustor was cooled, bed material removed from the north reinjection vessel, and the gas turbine tripped at 03:49 hours.

6. Start-Up TD-SU-93-10-01 August 18 - August 24, 1993

The combustor was released at 15:45 hours on August 18.

The unit was started for the purpose of testing sorbent utilization using limestone for sorbent.

The gas turbine was rolled at 02:58 hours, paralleled at 03:15 hours, and the gas turbine valves opened at 03:25 hours on August 18.

The bed preheater was lit at 11:34 hours.

A coal fire was initiated at 17:48 hours and sorbent injection started at 18:52 hours.

The south bed ash reinjection vessel outlet plugged and no material could be injected into the bed from it.

Bed level was increased and once-through operation achieved at 22:54 hours.

A sorbent utilization test was conducted on August 21 at 115-inch bed level with 95% sulfur retention.

On August 23, the coal paste water content was raised for a test.

Limestone, as sorbent, was started into the preparation system and this absorbent entered the bed at approximately 22:00 hours on August 23. At approximately 05:00 hours on August 24, the bed density showed signs of sintering in the bed. By 08:00 hours, the bed temperatures also indicated

the presence of sinters. Limestone sorbent injection was aborted. The sorbent fines admission system was started as absorbent and bed ash reinjection was used to try to displace the sintered bed, but high temperatures in the evaporator section of the boiler could not be controlled. The combustor was manually tripped at 13:28 hours.

The combustor was cooled and all bed material was removed. (Neither of the bed ash reinjection vessels could be emptied due to plugged "L" valves.)

7. Start-Up TD-SU-93-11-01 August 29 - September 23, 1993

The combustor was released at 19:15 hours on August 28.

The unit was started for the purpose of performance testing with various dolomites as absorbent.

The gas turbine was rolled at 09:22 hours, paralleled at 09:41 hours, and the gas turbine valves opened at 09:47 hours on August 29.

The bed preheater was lit at 18:06 hours.

Fuel injection was attempted at 22:10 hours but the No. 3 pump did not start. The pumps were reversed, lines clean blown and wetted, and a successful coal fire was attained at 23:31 hours on August 29 (No. 3 pump again did not start, but was placed in service at 00:49 hours on August 30). Sorbent injection started at 18:52 hours on August 30.

Bed level was increased and once-through operation achieved at 05:04 hours.

Bed level was maintained at 100 inches while the bed matured and the remaining sand was removed from the bed ash reinjection system.

During this time, the sorbent prep system crusher speed was increased to test the effect on the product size distribution.

Following the maturing period, the bed was raised to 115 inches and the sorbent fines admission system was placed in service with a ratio of 14 kpph sorbent to 60 kpph coal. While using this system, the rotary feeder at the 500 ton storage vessel bound up several times until temporary seal air from the dry air system was used.

Two performance tests were conducted while using the fines in the paste, one at 115-inch bed level with 90% sulfur retention and the other at 80-inch bed level with 90% sulfur retention.

The APF manway vibrator stopped operating and later failed with a leak in the internal hoses and required isolation.

The east sorbent injection velocity transmitter showed considerably less flow than the orifice flowmeter and all attempts to correct the problem failed. The flow control valve was limited to 83% opening to reduce the high velocity through this line for the remainder of the run.

Both "L" valves in the bed ash removal system were restricted in flow. Inspection of the valves showed a sparge duct tile in each valve. Removal of these tiles allowed the bed ash removal system to function normally for the remainder of the run.

On September 9, bed level was reduced to 45 inches to clean up the APF (differential pressure had increased to 250 inches of water). Following the clean up, the differential was 100 inches of water.

Unit load was increased to 115-inch bed level and a performance test conducted at 85% sulfur retention with Peebles dolomite as the absorbent. Tests were also done with Peebles dolomite at 80-inch bed level with 90% sulfur retention and at 80-inch bed level with 95% retention.

On September 13, ash leakage was detected at the backup cyclone indicating broken candles. Problems were also encountered with getting ash out of the APF and the APF ash removal system (candles were blocking the piping). High ash level alarms in the APF were in and out for the remainder of the run. Various tactics were used to remove the ash from the APF during this time.

During the night of September 13, the sorbent injection system developed a leak in the piping upstream of the boiler isolation valves. After much effort, the piping was isolated sufficiently to allow repairs. Sorbent injection was out of service for approximately seven hours. During this time, the sorbent fines admission system was started into the paste to reduce sulfur emissions. The bed showed signs of sintering during and following this period of time. After returning sorbent injection to service, the bed stabilized. National Lime and Stone Carey dolomite was then introduced to the system.

Two performance tests were run on National Lime Carey dolomite. The first was at 80-inch bed level with 95% sulfur retention, and the second was at 80-inch bed level with 90% sulfur retention.

Battelle Research was on site September 16 to collect ash samples from the APF inlet gas stream. Problems were encountered with the sampler. The seal leakage on the sampler was excessive, the sample valve manual operator broke with the valve stuck half open, and the sampler probe stuck. Attempts to close or open the valve were unsuccessful and Leak Repair, Inc. was called to seal the probe leak and abandon it in place until the next outage.

The No. 11 primary cyclone spoiling air system was tested on September 17. Spoiling flow was increased to its maximum of 5700 PPH with the expected results of the suction nozzle and dip leg nozzle temperature decreases. No sign of a dip leg fire was seen.

After the Carey dolomite was purged through the preparation system, the drying mill sheave was changed again to increase the speed of the crusher.

On September 20, unit load was decreased to 45-inch bed level to do a clean up on the APF candles (differential pressure had increased to 240 inches of water). This attempt to reduce the differential pressure was not as successful as the last time and the filter differential pressure was only lowered to 140 inches of water.

The APF high level was in and out several times and remained in for about twenty-four hours following the clean up of the candles. The backup cyclone ash line also plugged and required blowing out with low pressure nitrogen. Several pieces of broken candle were removed from the APF lockhopper ash removal system when they plugged the transport line.

On September 21, unit load was increased to 116-inch bed level and the No. 11 primary cyclone spoiling air system initiated. The No. 2 HPT disc cooling air temperature increased to 860 degrees and the adjustable V6 orifice was opened and the disc cooling temperature lowered below alarm.

On the morning of September 22, shorted contacts on the raise/lower relays for the steam turbine load motor burned the supply voltage leads to the load motor control circuit. The turbine bypass valve was used to control throttle pressure while repairs were made to the load motor controls.

On September 22, unit load was raised to 128-inch bed level for a performance test at 90% sulfur retention with Greenfield dolomite.

APF ash production tests were done both with the No. 11 primary cyclone spoiling in service and out of service.

On the evening of September 23, the APF ash removal system plugged at the APF bottom. A high level alarm in the APF was received at 19:41 hours.

A leak developed on the sorbent injection piping downstream of HCV-B850 and the combustor was tripped at 20:12 hours.

The gas turbine was removed from service at 00:58 hours on September 24.

The combustor and APF were cooled and released to maintenance for outage activities at 01:53 hours on September 25.

B. Maintenance

1. Outage TD-OT-93-94 July 3 - July 4, 1993

Replaced batteries on LPT strain gauge telemetering equipment.

2. Outage TD-OT-93-95 July 5 - July 16, 1993

Gas Turbine:

Replace LPT test blades

Inspected No. 5 bearing for source of vibration

Ash Removal:

Inspected V-102

Inspected precipitator baghouse and lockhopper and cleaned

Hot Gas Clean Up:

Installed revised backpulse compressor blowdown tank

Added insulation to APF dome liner

Replaced APF hopper vibrator with a larger one

Installed overtemperature protection for closed cycle cooling water heater in NET-90

Miscellaneous:

Repaired motor on splitting air compressor

Modified splitting air compressor base supports to reduce vibration

Replaced pressure vessel to freeboard rupture disc

3. Outage TD-OT-93-06 August 5 - August 8, 1993

Repaired APF emergency ash line valves

Installed larger vibrator on APF hopper

Repaired splitting air compressor head leaks

Repaired leak on gas turbine crossunder pipe

4. Outage TD-OT-93-07 August 9 - August 10, 1993

Repaired north bed ash reinjection vessel vent valve (HCV-J235)

Installed balance shot on gas turbine HPT

5. Outage TD-OT-93-08 August 14, 1993

Cleaned No. 5 paste line nozzle

6. Outage TD-OT-93-09 August 15 - August 18, 1993

Repaired leaks on primary ash cooler water side flanges

Changed coal water mixer blades

Installed new valve in APF emergency ash line

Repaired insulation on APF clean gas ash sampler

Inspected V-102

Inspected LPT blade roots

Cleaned out No. 15 primary cyclone

Sandblasted cyclones

7. Outage TD-OT-93-10 August 24 - August 28, 1993

Replaced belt on Conveyor No. 2

Replaced bags on cyclone ash removal conveying bag filter

Installed new O₂ analyzer in GT outlet duct

Inspected No. 5 bed preheater burner

Repaired insulation on APF clean gas ash sampler

Cleaned bed ash reinjection "L" valves and inspected reinjection vessel

8. Outage TD-QT-93-11 September 23 - September 30, 1993

Inspected gas turbine LPT blade roots

Repaired leak in stack duct at breeching damper

Installed remainder of gas turbine inlet duct snow hoods

Installed sorbent injection distribution header inside boiler

Repaired sorbent injection piping outside combustor

Replaced coal water mixer blades

Replaced sorbent preparation crusher hammers

Repaired sorbent preparation cyclone inlet duct

Replaced leaking gaskets on primary ash system

Installed blanks to isolate HGCU from PFBC

V. MANPOWER REPORT

As of September 30, American Electric Power Service Corporation actual work-hours for the Phase III accounted for 34.8% 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 Third Quarter 1993 were \$2,477,707 versus \$3,334,000 forecasted. As of September 30, the cumulative cost shared expenditures for Phase I, II, and III were \$170,619,525.

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 third quarter 1993.

The following table summarizes the project expenditures as of September 30 of all participants:

	<u>DOE</u>	<u>OCDO</u>	<u>OPCO</u>	<u>Total Expended as of 9/30/93</u>
<u>Phase I</u>				
Design & Permitting	\$ 7,000,000	\$ 5,000,000	\$ 9,539,183	\$ 21,539,183
<u>Phase II</u>				
Construction & Start-up	\$47,000,000	\$ 5,000,000	\$ 69,957,156	\$121,957,156
<u>Phase III</u>				
Operation, Data Collection, Reporting & Disposition	<u>\$ 4,932,314</u>	<u>\$ -0 -</u>	<u>\$ 22,190,872</u>	<u>\$ 27,123,186</u>
Total:	\$58,932,314	\$10,000,000	\$101,687,211	\$170,619,525

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 \$17,125 and are summarized as follows:

<u>Purchase Order</u>	<u>Description (Contractor)</u>	<u>Contracted Costs</u>
08159	Analytical Investigation University of North Dakota	\$11,876
A-1474	Thermogravimetric Analysis University of North Dakotay	\$ 5,249

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	179.9		

\$ in Millions

[illegible]

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	1.080	0.059	0.0	5.081
Actual	0.080	0.320	0.339	0.918	0.573	0.437	0.488	0.587	0.391	0.348	0.451				4.932

Figure 4.

DATE

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4 / 14 / 94

END