JUN 0 1992

**CONFINED ZONE DISPERSION
FLUE GAS DESULFURIZATION DEMONSTRATION**

DOE/PC/90546--T4

DE92 018881

**Quarterly Report No. 4
For the Period
August 1, 1991 to October 31, 1991**

VOLUME I

**Prepared for:
U.S. Department of Energy
Pennsylvania Electric Company
Pennsylvania Energy Development Authority
New York State Electric & Gas Corporation
Rockwell Lime Company**

**Prepared by:
Bechtel Corporation
Fifty Beale Street
San Francisco, California 94105-1895**

February 27, 1992

**Cooperative Agreement No. DE-FC22-90PC90546
Patents Cleared by Chicago on March 2, 1992**

CONTENTS

VOLUME I

<u>Section</u>		<u>Page</u>
	LEGAL NOTICE	iii
1	INTRODUCTION	1-1
2	SUMMARY	2-1
3	PROJECT STATUS	3-1
	3.1 EQUIPMENT ACQUISITION AND INSTALLATION (WBS No. 1.2.1)	3-1
	3.2 FACILITY CONSTRUCTION (WBS No. 1.2.2)	3-1
	3.3 CZD PARAMETRIC TESTING (WBS No. 1.3.2)	3-1
	3.3.1 In-Duct Water Injection Tests	3-3
	3.3.2 In-Duct Lime Slurry Injection Tests	3-18
	3.3.3 Base Line Testing	3-28
	3.3.4 Problems/Issues	3-28
	3.4 MANAGEMENT AND TRAVEL (WBS No. 1.2.5)	3-3
4	PLANNED ACTIVITIES	4-1
	4.1 PHASE 2 - CONSTRUCTION AND START-UP	4-1
	4.2 PHASE 3 - OPERATION AND DISPOSITION	4-1
	4.3 PHASE 3 - PROJECT MANAGEMENT	4-2
Appendix A	DESCRIPTION OF PROJECT AND WORK BREAKDOWN STRUCTURE	A-1
	A.1 PROJECT DESCRIPTION	A-1
	A.2 WORK BREAKDOWN STRUCTURE DESCRIPTION	A-4
Appendix B	REPORT DISTRIBUTION LIST	B-1

VOLUME II

Appendix C	SUPPORTING DATA	C-1
------------	-----------------	-----

FIGURES

<u>Figure</u>		<u>Page</u>
3-1	Plan View of Duct with Thermocouple Locations	3-4
3-2	Typical Thermocouple Section	3-5
3-3	Temperature Profiles	3-7
3-4	Inspection Inside the Flue Gas Duct During Parametric Tests with Lime Slurry Injection	3-24

TABLES

<u>Table</u>		<u>Page</u>
3-1	In-Duct Water Injection, Summary for August and September 1991	3-17
3-2	In-Duct Opacity Data, September 1991	3-19
3-3	Estimate of SO ₂ and NO _x Removal	3-27
3-4	Lime Slurry Injection Factorial Tests, CZD Activity Summary for October 1991	3-29
A-1	Work Breakdown Structure (WBS) Diagram	A-3

LEGAL NOTICE

This report was prepared by Bechtel Corporation, pursuant to a Cooperative Agreement partially funded by the U.S. Department of Energy, and neither Bechtel Corporation, nor any of its subcontractors nor the U.S. Department of Energy, nor any person acting on behalf of either:

- (A) Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately-owned rights; or
- (B) Assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method or process disclosed in this report.

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 U.S. Department of Energy. The views and opinions of authors expressed herein do not necessarily state or reflect those of the U.S. Department of Energy.

Section 1

INTRODUCTION

The confined zone dispersion (CZD) process involves flue gas post-treatment, physically located between a boiler's outlet and its particulate collector, which in the majority of cases is an electrostatic precipitator. The features that distinguish this process from other similar injection processes are:

- Injection of an alkaline slurry directly into the duct, instead of injection of dry solids into the duct ahead of a fabric filter.
- Use of an ultrafine calcium/magnesium hydroxide, type S pressure-hydrated dolomitic lime. This commercial product is made from plentiful, naturally occurring dolomite.
- Low residence time, made possible by the high effective surface area of the Type S lime.
- Localized dispersion of the reagent. Slurry droplets contact only part of the gas while the droplets are drying, to remove up to 50 percent of the SO₂ and significant amounts of NO_x. The process uses dual fluid rather than rotary atomizers.
- Improved electrostatic precipitator performance via gas conditioning from the increased water vapor content, and lower temperatures. Supplemental conditioning with SO₃ is not believed necessary for satisfactory removal of particulate matter.

The waste product is composed of magnesium and calcium sulfite and sulfate, with some excess lime. This product mixed with fly ash is self-stabilizing because of the excess lime values, and thus tends to retain heavy metals in insoluble forms within the fly ash.

The demonstration is being conducted at Penelec's Seward Station, Unit No. 15. This boiler is a 147 Mwe coal-fired unit, which utilizes Pennsylvania bituminous coal (approximately 1.2 to 2.5% sulfur). One of the two flue gas ducts leading from the boiler has been retrofitted with the CZD technology.

The goal of this demonstration is to prove the technical and economic feasibility of the CZD technology on a commercial scale. The process is expected to achieve 50% SO₂ removal and possibly 30-40% NO_x removal at lower capital and O&M costs than other systems.

The U.S. Department of Energy and Bechtel Corporation are engaged in a cooperative project to demonstrate the CZD Technology. DOE is providing half,

or \$4.6 million, of the project's total \$9.2 million cost. Others contributing to the project are Pennsylvania Electric Company (\$3 million), Bechtel (\$760,000), the Pennsylvania Energy Development Authority (\$750,000), New York Gas and Electric Company (\$100,000), and Rockwell Lime Company (\$23,000).

To achieve its objectives, the project is divided into the following three phases:

Phase 1: Design and Permitting

Phase 2: Construction and Start-up

Phase 3: Operation and Disposition

Phase 1 activities were completed on January 31, 1991. Phase 2 activities were essentially concluded on July 31, 1991, and Phase 3a, Parametric Testing, was initiated on July 1, 1991. This Quarterly Technical Progress Report covers Phase 2 and Phase 3a activities from August 1, 1991 through October 31, 1991.

For further information on the structure of this demonstration project, Appendix A provides a project description by phase, Work Breakdown Structure (WBS) Diagram, and a detailed description of the WBS.

Section 2

SUMMARY

This is the fourth quarterly report for this project and it covers work performed on Phases 2 and 3a of the project from August 1, 1991 through October 31, 1991. Phase 2, which is essentially complete, included equipment acquisition and installation, facility construction, and start-up operations. Phase 3a covers the parametric test period and includes:

- Testing and calibration of the atomizers outside the duct
- In-duct water injection tests to establish and define the confined zone
- In-duct lime slurry injection tests for SO₂ and NO_x reduction
- Evaluating the performance of electrostatic precipitators (ESP) during parametric tests, and consulting with ESP experts, if necessary, to improve performance
- Evaluating the effects of process variables on emission control performance
- Determining operating conditions for optimum overall performance
- Evaluating the effects of using alternative coals and reagents:
 - High and medium sulfur coals
 - Alternate reagents including pressure-hydrated dolomitic lime, hydrated calcitic lime, and fresh slaked calcitic lime

At the conclusion of parametric testing (end of Budget Period 1), additional plant modifications will be required to permit handling the larger volume of lime needed during the continuous one-year CZD demonstration. Additional instrument and control changes will also be necessary to automate the CZD system and completely integrate its operation with Seward Station Unit No. 15. These modifications and changes will be incorporated during Phase 3b (Budget Period 2) which also includes the one-year continuous demonstration period.

Phase 2 activities were scheduled to be completed by mid-May, and were covered in the previous quarterly report. Although virtually all CZD process equipment was installed and checked out by July 1, 1991, two items were incomplete - soot blowers and thermocouples. The Zack Company completed installation of the soot blower wiring and piping, and the thermocouples and thermocouple wiring by August 16, 1991.

Phase 3a was initiated early in March with wind tunnel testing of atomizer nozzles at U. C. Davis. As a result of the delays described above, the parametric test program has been re-scheduled as follows:

PARAMETRIC TEST PROGRAM

Original and Current Schedules

		June				July				August				September				October				November				December					
		7	14	21	28	5	12	19	26	2	9	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22	29	6	13	20	27
Calibration of atomizing nozzles, duct velocity traverses, final leak checks	Original Plan																														
	Current Plan																														
Factorial water tests in flue gas duct	Original Plan																														
	Current Plan																														
Factorial dolomitic lime injection tests	Original Plan																														
	Current Plan																														
Factorial calcitic lime injection tests	Original Plan																														
	Current Plan																														

The current plan is based on working some overtime hours and assumes no major boiler outages or equipment failures. With careful test planning and some rearrangement of individual tests, it is believed the parametric test program can be completed by the end of December.

Section 3

PROJECT STATUS

This section of the report provides details of the work performed from August 1, 1991 through October 31, 1991, covering equipment acquisition and installation, facility construction, construction management, project management and travel. It also describes the initial activities carried out as part of the parametric test program.

3.1 EQUIPMENT ACQUISITION AND INSTALLATION (WBS No. 1.2.1)

Procurement and installation of all major equipment and instruments required for the CZD system has been completed. The status of individual items is described below:

- Air compressors, receiver, and electric power supply - complete, tested, and ready for service.
- Atomizers - lance and atomizer assemblies are complete, water testing/calibration was done.
- Instruments and controls - surface thermocouples have been installed on the duct bottom and sides, probe thermocouples were shipped in early August. The Zack Company installed the thermocouples in their test ports and wired them to the multipoint recorders. They also wired the surface thermocouples to the multipoint recorder. All remaining instrument hook-ups were completed by the last week in August, including the Bailey Infi 90 system for data acquisition, monitoring, and analysis. The continuous emissions monitoring system (CEMS) needed to control and evaluate the performance of the CZD system was installed by Penelec's environmental services group and was operational by the end of September.
- Lime feed and transfer system - complete, tested, and ready for service.

3.2 FACILITY CONSTRUCTION (WBS No. 1.2.2)

This item is complete and has been in satisfactory operation since May 5, 1991.

3.3 CZD PARAMETRIC TESTING (WBS No. 1.3.2)

The principle of the confined zone is to form a wet zone of fine droplets in the middle of the duct, confined in an envelope of hot gas that separates the wet zone from the duct walls. The atomized lime slurry is injected in the center of the flue gas duct parallel to the flow of gas. As the cone of atomized lime slurry moves downstream and expands, the flue gas within the cone cools and its SO₂ is

rapidly absorbed by the still-liquid atomized droplets. The atomized droplets in the expanding cone diffuse outward by eddy diffusion. However, since the outward diffusing droplets continuously contact hot gas at about 300°F, they rapidly achieve surface dryness. During this drying period, the hydrated lime solution reacts quite rapidly with the SO₂ absorbed by the water, and additional lime is rapidly dissolved into solution from the very small particles of hydrated lime.

The turbulent flow also causes hot flue gas surrounding the cone of atomized slurry to diffuse inward and evaporate droplets on the inside of the cone. At a certain point downstream of the injection point, the free moisture in the atomized slurry has evaporated completely, and the dry solids remaining can contact surfaces of the duct or the turning vanes without adhering and causing deposits to accumulate.

The thickness of the layer of flue gas that envelopes the wet zone, separating it from the duct walls, could determine the percentage of SO₂ removal. A hot flue gas layer uniformly 18 inches thick along the duct walls will limit the SO₂ removal to about 40 percent, a 12-inch layer will limit SO₂ removal to about 52 percent and a 6-inch layer to about 68 percent. Therefore, arrangement of the atomizer lances inside the flue gas duct to create the thinnest hot flue gas layer along the duct walls, without causing deposits of solids on the walls, will assure the highest percentage of SO₂ removal. This is because more flue gas in the duct will be reacting with the atomized lime slurry.

The atomizers selected for CZD testing were developed and calibrated at U.C. Davis to determine their pressure/flow characteristics for very fine mist formation. Then the atomizers, assembled in lances, were tested outside the duct to verify their pressure/flow characteristics at different water flow rates (1-5 gpm) and the effect of the impact between the mists of adjacent atomizers.

The next step in the program included testing the calibrated atomizers assembled on eight lances in the flue gas duct. In total, 20 atomizers are installed in the duct. Each atomizer can reliably atomize water or lime slurry with a flow rate of 1-4 gpm. For a 50 percent SO₂ removal, we estimate that about 50 gpm of lime slurry must be atomized in the flue gas duct at Seward Station.

The atomizer lances are installed through nozzle ports on top of the ductwork. Each lance contains the compressed air and liquid feed pipes for the atomizers. Four lances contain three atomizers each (numbered from 1 to 12) and four lances contain two atomizers each (numbered from 13 to 20). The water injection tests in the flue gas duct will determine the atomizers' configuration to avoid wetting the duct and the turning vanes.

The dimensions of the plume resulting from injection are determined by thermocouple lances (with six thermocouples each) taking multipoint temperature traverses of the duct cross section at several locations downstream of the inject point. Figure 3-1 shows the position of the four cross sections of the thermocouple lances and their distances from the injection point. The cross section closest (65 ft) to the injection point is named Section B; the farthest (222 ft) is named Section E. (Elsewhere in this document, the sections are referred to as rows or groups, as well as sections.) In total, there are 96 thermocouples in the four cross sections that measure and record the flue gas temperature 65 ft, 120 ft, 186 ft, and 222 ft from the injection point. Figure 3-2 shows the typical thermocouple section with six thermocouples per thermowell, a total of 24 per section.

In addition to these thermocouples connected to the chart recorders, there are 120 thermocouples incorporated in 20 lances. These can be distributed along both sides of the duct, with 10 lances (60 thermocouples) measuring the flue gas temperature 6 inches from the duct side walls, and 10 lances (60 thermocouples) installed two feet from the side walls. These portable lances are provided with hand readout instruments for flue gas temperature reading.

Another 20 thermocouples measure the temperature of the outside duct walls (bottom and sides). These temperatures are continuously recorded by the chart recorder. If by accident water or lime slurry drips to the bottom of the flue gas duct, these "skin" thermocouples will alarm at temperatures lower than 110°F.

3.3.1 In-Duct Water Injection Tests

Testing with atomized water inside the duct was performed to determine the maximum amount of water that can be injected into the duct without cooling the duct walls. The thermocouple lances along the duct walls and those at the four duct cross sections at different distances from the injection point help determine the optimum position of the atomizer lances in the flue gas duct, and the maximum amount of atomized water that could be injected without cooling the duct walls. Another objective of the water injection in the duct was to determine the effect of cooling the flue gas and increased amounts of water vapor on the ESP particulate removal efficiency, and the percentage of opacity.

With so many thermocouples in the flue gas duct continuously showing the flue gas temperature in the duct with or without water injection, it is possible to determine the best orientation of atomizers for maximum water rate without wetting the duct walls or the turning vanes.

Figure 3-1 Plan View of Duct with Thermocouple Locations

Figure 3-2 Typical Thermocouple Section
(6 thermocouples per thermowell = 24 per section)

Ten graphs (Figure 3-3) show the temperature profile at each of the four sections (B, C, D, and E) before water injection on August 14, 1991, and during the water injection test of September 26, 1992. Before water injection, i.e., during the normal boiler operation at full load (147 MW), the graphs show that the highest temperature, 284°F, is at Section B in the center of the duct, and the lowest temperature, 256°F, is at the bottom of the duct. The difference between the highest and the lowest temperature in the duct at Section B is about 28°F. The difference is 26°F at Section C and 16°F at Sections D and E. There are also temperature differences between the right side and the left side of the duct, close to its walls, and between the upper side and the bottom of the duct. Because of these temperature variations of the flue gas inside the duct, the arrangement, the orientation, and the water or lime slurry flow rate for each atomizer were developed during the water injection testing.

The temperature profile in the duct during water injection shows the following:

- At Section B, about 65 feet from the injection point, the center of the duct is wet at 120°F (at the adiabatic saturation temperature), and close to the side walls and bottom and top of the duct the temperature of the flue gas is close to 200°F. The hot zone along the duct walls confines the wet dispersion zone, preventing it from reaching the duct walls; therefore, no wet deposits form on the duct walls. The theoretical "confined zone dispersion" (CZD) is now proved in practice.
- At Section C, about 120 feet from the injection point, and close to the turning vanes, the temperature at the center of the duct is above 160°F, which means that the wet zone has become dry, and no deposits could form on the turning vanes. The duct walls are at temperatures close to 200°F.
- At Section D, about 186 feet from the injection point and at Section E, about 222 feet from the injection point, the temperature of the flue gas is above 170°F and the highest temperature is 182°F. The flue gas is moving into the ESP at this temperature, at an approach to saturation above 60°F. Under these conditions, the deposition of wet solids on the collecting plates and the discharge wires in the ESP is completely eliminated.

Water injection in the duct for the months of August and September 1991 is summarized in Table 3-1.

The daily test data for in-duct water injection are included in Volume II, Appendix C, Section 1.

Temperature Profile – Before Injection

Figure 3-3 Temperature Profiles

Temperature Profile – Row “B” Before Injection

August 14, 1991

Figure 3-3 Temperature Profiles (Cont'd)

Temperature Profile – Row “C” Before Injection

August 14, 1991

Figure 3-3 Temperature Profiles (Cont'd)

Temperature Profile – Row “D” Before Injection

August 14, 1991

Figure 3-3 Temperature Profiles (Cont'd)

Temperature Profile – Row “E” Before Injection

August 14, 1991

Figure 3-3 Temperature Profiles (Cont'd)

Temperature Profile – After Injection

Figure 3-3 Temperature Profiles (Cont'd)

Temperature Profile – Row “B” 40.8 gpm

September 26, 1991

Figure 3-3 Temperature Profiles (Cont'd)

Temperature Profile – Row "C" 40.8 gpm

September 26, 1991

Figure 3-3 Temperature Profiles (Cont'd)

Temperature Profile

Row "D" 40.8 gpm

September 26, 1991

1:04.1/1

Figure 3-3 Temperature Profiles (Cont'd)

Temperature Profile Row "E" 40.8 gpm

September 26, 1991

11/94-1/2

Figure 3-3 Temperature Profiles (Cont'd)

Table 3-1

**In-Duct Water Injection
Summary for August and September 1991**

	Time		Duration	Water Atomized		
Date	Start	Stop	Hours	G.P.M.	Gallons	Comments
August 1991						
8/23	9:30 a.m.	15:00 p.m.	5.5 Hours		3,100	
8/26	10:20 a.m.	17:15 p.m.	3 Hours	15-35	4,500	
8/27	10:45 a.m.	13:45 p.m.	3 Hours	30-35	5,700	
8/28	14:15 p.m.	17:30 p.m.	3:15 Hours	20-35	5,400	
8/29	11:30 a.m.	18:10 p.m.	6 Hours	20-35	9,500	
8/30	9:00 a.m.	13:00 p.m.	4 Hours	20-49	7,200	
September 1991						
9/3	12:00 a.m.	17:00 p.m.	5 Hours	20-40	9,000	Progress Rev. Mtg. Boiler #15 Down Boiler #15 Down

Opacity Data During In-Duct Water Injection

Opacity data were collected from two continuous opacity monitoring instruments.

- An in-duct continuous opacity monitor located at the outlet of the electrostatic precipitator serving the CZD test duct. (Unvalidated hourly data for September 27 and a summary for the month of September are presented in Table 3-2.)
- An in-stack continuous opacity monitor used to demonstrate compliance with environmental permit conditions.

Reproductions of the daily in-stack continuous opacity monitor recorder charts are shown in Volume II, Appendix C, Section 2. Each chart records in-stack opacity for a day during which water was injected into the CZD test duct. The start and stop times when water injection occurred are marked on the chart reproduction. In each case, a consistent decrease in measured opacity during the period when water was injected was observed.

3.3.2 In-Duct Lime Slurry Injection Tests

After the program of testing water injection inside the duct was completed, the program of testing the atomized lime slurry duct injection was started.

We intended to start the testing with Type S lime (pressure-hydrated dolomitic lime) which is a fast SO₂ absorbent, but because the lime silo was about half full of dry hydrated calcitic lime, we decided to start operating with this type of lime until all of it was consumed and the silo could be filled with type S lime.

The dry hydrated calcitic lime was slurried with water in a sump at about 20 percent lime concentration, pumped to a vibrating screen to remove the impurities, and discharged by gravity into one of the two lime slurry feed tanks.

Using calcitic lime, slurry injection tests were conducted during October with encouraging results. Plans and strategies were developed for resolving the current problem areas and for expanding the parametric test program to include continuous automated testing.

Significant accomplishments:

- A total of 13 lime slurry injection tests was completed between October 10 and October 31, 1991.
- Lime slurry feed rates were varied from 30 gpm to 49 gpm and lime slurry concentrations were varied from 2.2% to 14.5%.

Table 3-2

In-Duct Opacity Data, September 1991

Prior to Water Injection

6:58 a.m.	No injection	AT-100	Duct instant opacity	13.78%
		AT-200	Stack instant opacity	11.44%
		CA-100	Duct 1 minute avg.	16.21%
		CA-200	Stack 1 minute avg.	?
7:28 a.m.	No injection	AT-100	Duct instant opacity	18.30%
		AT-200	Stack instant opacity	14.71%
		CA-100	Duct 1 minute avg.	16.66%
		CA-200	Stack 1 minute avg.	?
7:58 a.m.	No injection	AT-100	Duct instant opacity	12.66%
		AT-200	Stack instant opacity	11.74%
		CA-100	Duct 1 minute avg.	17.48%
		CA-200	Stack 1 minute avg.	?
8:28 a.m.	No injection	AT-100	Duct instant opacity	16.94%
		AT-200	Stack instant opacity	13.02%
		CA-100	Duct 1 minute avg.	17.82%
		CA-200	Stack 1 minute avg.	?
8:58 a.m.	No injection	AT-100	Duct instant opacity	14.14%
		AT-200	Stack instant opacity	12.63%
		CA-100	Duct 1 minute avg.	20.12%
		CA-200	Stack 1 minute avg.	?
9:28 a.m.	No injection	AT-100	Duct instant opacity	14.48%
		AT-200	Stack instant opacity	12.27%
		CA-100	Duct 1 minute avg.	19.21%
		CA-200	Stack 1 minute avg.	?
9:34 a.m.	No injection	AT-100	Duct instant opacity	17.39%
		AT-200	Stack instant opacity	14.98%
		CA-100	Duct 1 minute avg.	17.32%
		CA-200	Stack 1 minute avg.	?

Table 3-2
Opacity Data for September 27, 1991
(Cont'd)

Start Water Injection: 9:20 a.m.

9:48 a.m.	28 gpm	AT-100	Duct instant opacity	15.27%
		AT-200	Stack instant opacity	13.74%
		CA-100	Duct 1 minute avg.	15.6%
		CA-200	Stack 1 minute avg.	?
10:21 a.m.	32 gpm	AT-100	Duct instant opacity	7.22%
		AT-200	Stack instant opacity	7.70%
		CA-100	Duct 1 minute avg.	9.11%
		CA-200	Stack 1 minute avg.	9.03%
10:34 a.m.	35 gpm	AT-100	Duct instant opacity	6.82%
		AT-200	Stack instant opacity	7.62%
		CA-100	Duct 1 minute avg.	7.05%
		CA-200	Stack 1 minute avg.	8.14%
11:04 a.m.	39 gpm	AT-100	Duct instant opacity	8.89%
		AT-200	Stack instant opacity	8.85%
		CA-100	Duct 1 minute avg.	6.52%
		CA-200	Stack 1 minute avg.	8.30%
11:34 a.m.	39 gpm	AT-100	Duct instant opacity	4.91%
		AT-200	Stack instant opacity	8.55%
		CA-100	Duct 1 minute avg.	6.39%
		CA-200	Stack 1 minute avg.	8.265%

Shutdown Water Injection: 11:38 a.m.

13:04 p.m.	-	AT-100	Duct instant opacity	18.85%
		AT-200	Stack instant opacity	11.55%
		CA-100	Duct 1 minute avg.	20.82%
		CA-200	Stack 1 minute avg.	14.50%

Table 3-2
Opacity Data for September 27, 1991
(Cont'd)

Start Water Injection: 1:25 p.m.

1:34 p.m.	24 gpm	AT-100	Duct instant opacity	17.27%
		AT-200	Stack instant opacity	12.48%
		CA-100	Duct 1 minute avg.	19.74%
		CA-200	Stack 1 minute avg.	13.58%
14:04 p.m.	30 gpm	AT-100	Duct instant opacity	14.93%
		AT-200	Stack instant opacity	12.45%
		CA-100	Duct 1 minute avg.	14.92%
		CA-200	Stack 1 minute avg.	12.76%
14:34 p.m.	35 gpm	AT-100	Duct instant opacity	8.65%
		AT-200	Stack instant opacity	8.07%
		CA-100	Duct 1 minute avg.	8.24%
		CA-200	Stack 1 minute avg.	9.21%

Table 3-2
(Cont'd)

MONTHLY REPORT

(O_0P /PER SUMMAY DATA REPORT)

PENNSYLVANIA ELECTRIC COMPANY
DATE: SEPTEMBER 1991

SITE: SEWAKO CZD
PARAMETER: O_0P

(10)

TIME PERIOD IN HOURS - MIDNIGHT TO MIDNIGHT

HRS	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	AVG
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
1	4.6	4.4	4.8	5.1	5.1	4.8	4.6	4.4	4.1	4.2	4.4	4.8	4.9	4.9	5.1	5.0	4.9	4.9	4.7	4.2	4.7	5.1	4.1	3.9	4.7
2	3.8	3.8	3.9	4.1	4.0	4.0	3.9	3.8	4.0	4.1	4.3	4.1	4.2	4.4	4.5	4.5	4.5	4.5	4.4	3.9	3.9	4.0	3.7	3.5	4.1
3	3.6	3.5	3.6	3.8	3.6	3.5	3.5	3.6	3.7	3.9	4.5	4.6	3.9	4.2	4.5	4.7	5.0	7.3	7.5	6.8	6.4	6.0	6.5	5.3	4.7
4	3.9	3.8	3.8	4.1	4.1	4.1	5.1	5.1	4.9	4.4	4.6	4.8	6.1	4.4	3.9	3.8	11.2	4.5	6.3	6.6	6.3	6.6	6.2	6.1	5.2
5	5.8	5.0	4.8	5.0	4.9	5.1	5.4	5.7	5.1	5.2	5.1	5.7	5.9	6.1	5.0	4.9	5.1	4.8	6.0	6.4	6.1	5.5	5.2	4.8	5.4
6	4.3	4.0	4.1	4.6	4.7	4.6	4.6	4.5	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
7	4.4	4.0	3.8	3.8	3.6	4.3	4.5	4.5	4.5	4.8	5.2	5.5	5.8	5.0	4.8	4.9	5.0	5.1	5.1	5.0	4.6	4.4	4.3	4.0	4.6
8	3.6	3.5	3.5	3.4	3.4	3.8	4.1	4.0	4.1	4.6	4.7	5.0	5.3	4.7	4.3	4.6	4.5	4.7	4.6	4.5	4.4	4.3	4.2	4.1	4.2
9	4.0	3.8	3.7	3.6	3.6	4.1	4.3	4.2	4.4	4.6	4.8	5.0	5.3	5.1	4.7	4.7	4.8	4.7	4.8	4.8	4.5	4.3	4.3	4.2	4.4
10	4.0	3.8	3.7	3.7	3.6	4.4	4.6	4.5	4.6	4.7	4.7	4.8	4.7	4.7	4.4	4.5	4.3	4.4	4.4	4.3	4.3	4.2	4.2	4.2	4.3
11	4.2	4.2	3.9	4.0	3.9	3.9	4.4	4.1	4.0	4.1	4.2	4.3	4.3	4.3	4.1	4.2	4.2	4.3	4.3	4.2	4.0	3.8	4.2	3.9	4.1
12	3.8	3.7	3.7	3.6	3.6	3.6	4.2	4.1	4.1	4.4	4.4	4.7	4.8	5.0	4.1	4.4	4.8	4.8	5.1	4.8	3.8	3.0	3.4	2.7	4.1
13	2.6	2.5	2.3	2.3	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
14	2.6	2.5	2.3	2.3	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
15	2.6	2.5	2.3	2.3	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
16	11.3	13.0	13.5	13.9	14.7	14.8	14.4	14.5	13.8	12.4	11.7	9.7	12.6	10.2	9.0	13.5	13.9	13.1	13.4	16.6	18.4	17.7	19.0	18.8	13.9
17	18.0	18.1	18.0	16.1	17.8	17.9	18.8	18.8	19.3	19.0	19.4	15.7	19.6	15.4	8.8	18.6	18.9	19.1	18.5	18.5	18.6	17.9	17.5	19.0	17.8
18	18.7	17.8	16.8	16.5	17.4	16.3	15.6	17.9	19.6	18.9	17.3	12.4	18.9	12.9	8.1	17.2	20.0	18.9	19.0	18.2	17.9	18.0	17.8	17.6	17.1
19	16.7	16.9	18.7	18.0	17.5	17.5	16.5	16.7	15.4	16.0	16.8	12.0	16.7	12.0	7.9	9.0	18.3	19.5	20.5	19.3	19.1	18.5	17.6	16.8	16.4
20	14.6	14.0	13.3	12.6	11.4	11.0	12.7	12.6	12.8	13.3	11.7	9.2	16.2	12.0	8.5	14.7	15.9	15.4	15.4	15.2	15.2	14.9	14.8	12.8	13.3
21	10.7	10.6	10.5	9.9	9.5	9.4	9.3	10.1	10.8	12.1	13.5	12.9	11.9	10.3	10.4	9.5	9.0	10.6	11.9	12.3	11.9	11.9	11.7	9.4	10.8
22	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.3	1.2	1.2	1.0	1.0	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9
23	8.1	7.9	7.8	7.9	7.3	8.2	11.0	11.2	11.4	11.0	11.3	9.4	11.4	9.2	7.8	8.7	13.3	13.2	13.2	13.1	12.7	12.2	12.3	12.3	10.5
24	10.0	8.9	8.6	8.5	8.4	9.0	10.4	10.1	10.7	10.4	9.0	8.8	12.5	9.6	8.3	8.3	7.5	9.7	14.2	13.6	13.4	13.1	10.4	9.5	10.1
25	8.3	8.2	7.2	7.3	10.5	11.2	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
26	13.6	16.3	18.2	20.6	16.1	14.1	16.6	22.4	21.7	21.2	20.7	21.2	20.5	21.6	13.9	6.6	10.7	19.7	19.9	20.6	19.8	21.3	21.2	19.7	18.3
27	15.1	14.8	15.0	14.6	14.5	16.3	18.3	17.5	16.9	15.9	7.9	9.2	17.7	19.1	9.8	6.9	7.2	19.2	20.0	20.0	20.0	21.2	20.9	19.4	15.5
28	13.8	14.3	13.7	13.5	13.2	13.1	12.6	16.5	19.2	18.8	18.6	17.4	13.5	13.1	13.2	12.4	11.5	11.6	15.9	15.9	14.7	13.7	12.2	12.2	14.5
29	9.1	9.6	9.4	9.3	9.3	9.2	9.3	9.1	8.5	8.6	8.7	11.7	14.1	13.1	12.6	12.2	11.7	10.9	10.4	10.2	10.4	10.6	9.9	7.2	10.2
30	7.0	7.9	7.5	7.6	7.6	11.7	12.0	10.8	10.8	10.4	10.2	7.9	7.6	7.2	7.7	14.9	16.2	14.6	14.7	14.6	13.7	13.8	13.8	14.3	11.0
AVG	8.2	8.2	8.2	8.2	8.1	8.5	8.8	9.3	9.4	9.4	8.8	8.5	10.1	8.8	7.1	8.2	9.4	10.0	10.4	10.3	10.3	10.0	9.8	9.4	9.1
DAYS	30	30	30	30	30	30	30	30	30	30	28	29	28	28	29	29	29	29	29	29	29	30	30	30	706

TOTAL HOURS = 720 NUMBER OF GOOD HOURS = 706 NUMBER OF MISSING HOURS = 14 DATA CAPTURE = 98.1% TOTAL AVERAGE = 9.1
 AAAAA INDICATES INVALID DATA, SEE INVALID DATA REPORT FOR INDIVIDUAL HOUR ERROR

- Indicated SO₂ removal rates of up to 32% have been achieved. The SO₂ removal rate increases sharply as the concentration rises above 8% and the total injection rate approaches 50 gpm.
- Although there are indications of significant removal of NO_x, the data is questionable due to problems experienced with NO_x instrument calibration.

Opacity Data During In-Duct Lime Slurry Injection

Opacity during lime injection has been very low; in fact, the opacity decreases during injection. However, when injection is stopped, the opacity readings increase to higher levels than before injection. The reason for this phenomenon is being investigated, and temporary measures have been taken to insure that opacity does not exceed allowable limits.

Reproductions of the daily in-stack continuous opacity monitor recorder charts are shown in Volume II, Appendix C, Section 4. Each chart records in-stack opacity for a day during which lime slurry was injected into the CZD test duct.

Duct inspections conducted before lime injection and at two intervals after lime injection indicated general cleanliness of the duct with no evidence of buildup or heavy deposits. The soot blowers installed in the bottom of the duct appear to be functioning satisfactorily, and no manual duct cleaning has been required so far.

Photos taken during the duct inspection conducted before the end of October 1991, while the lime slurry injection tests were being made, are shown on Figure 3-4. These photos show a relatively clean duct.

The estimates of SO₂ and NO_x removal and the determination of percentage of lime utilization are made based on measured quantities of:

- SO₂, NO_x, and O₂ concentration in inlet and outlet flue gas
- Flue gas flow at the discharge from the test duct
- Barometric pressure
- Flue gas pressure
- Lime usage
- Lime slurry concentration
- Atomized air usage
- Dilution water usage

Table 3-3 shows the estimate of SO₂ and NO_x removal and percent lime utilization by Seward Station CZD system during the month of October 1991.

1.

View of the inside duct, about 30 ft. downstream of the injection point, looking in the direction of the gas flow. The fine ash powder on the bottom of the duct shows the footsteps. The photo also shows the sootblower nozzles and the thermocouples lances.

2.

This photo shows the cleanliness of the bottom and side walls of the duct.

Figure 3-4 Inspection Inside the Flue Gas Duct During Parametric Tests with Lime Slurry Injection

3.

This photo of the inside duct about 60 ft. downstream of the injection point. It shows the cleanliness of the bottom and walls of the duct.

4.

This photo shows the inlet to the turning vanes and the thermocouples lances in the cross-section "C" at about 120 ft. downstream of the injection point. It shows a slight ash deposit on the horizontal bar. The bottom and side walls are pretty clean and the turning vanes are also clean.

Figure 3-4 Inspection Inside the Flue Gas Duct During Parametric Tests with Lime Slurry Injection (Cont'd)

5.

This photo shows the perforated plate at the inlet of the second ESP, and the thermocouples lances at the cross-section "E." This is about 210 ft. from the injection point. The cleanliness of the total area at the second ESP inlet can be seen.

Figure 3-4 Inspection Inside the Flue Gas Duct During Parametric Tests with Lime Slurry Injection (Cont'd)

Table 3-3

Estimate of SO₂ and NO_x Removal

Type of Lime: CALCITIC % Ca(OH) ₂ = 96.07 % Mg(OH) ₂ = 0.00		FG	AA	WC	SO ₂ -IN	SO ₂ -OUT	NO _x -IN	NO _x -OUT	O ₂ -IN	O ₂ -OUT
		Flue Gas Flow Meter	Atomizing Air Meter	Water Content Of Slurry	Measured SO ₂ Conc. In	Measured SO ₂ Conc. Out	Measured NO _x Conc. In	Measured NO _x Conc. Out	Measured O ₂ Conc. In	Measured O ₂ Conc. Out
Date	Time	SCFM	SCFM	SCFM	PPMV	PPMV	PPMV	PPMV	Vol. %	Vol. %
10/10/91	13:15	260,000	1,350	5,180	905.8	703.9	383.2	313.9	6.160	7.400
10/11/91	13:30	268,000	1,350	5,127	868.6	660.5	400.2	328.0	6.230	7.380
10/14/91	14:15	252,000	1,350	5,054	891.1	665.9	423.9	326.6	6.200	7.520
10/15/91	10:30	255,000	1,350	4,933	898.8	642.2	377.4	314.4	6.270	7.450
10/15/91	14:45	255,000	1,350	4,863	935.2	698.5	366.8	312.2	6.025	7.450
10/16/91	15:35	262,000	1,270	5,454	894.2	655.4	394.0	321.9	6.033	7.500
10/22/91	12-15:00	265,000	1,258	5,673	930.7	648.4	403.7	317.4	6.100	7.700
10/23/91	11-15:45	267,000	1,466	6,335	929.9	664.5	391.8	300.1	5.900	7.600
10/24/91	12-16:00	267,000	1,273	6,862	898.6	603.7	488.8	299.5	6.020	7.620
10/28/91	11-14:45	266,500	1,273	6,729	904.2	583.5	422.1	310.1	6.100	7.710
10/29/91	11-15:55	257,600	1,273	6,605	878.2	516.9	354.9	284.6	6.110	7.680
10/30/91	13-16:45	263,029	1,067	7,889	918.2	615.6	355.8	283.1	5.850	7.470
10/31/91	13-16:00	264,500	1,157	8,526	860.2	603.8	314.5	307.6	6.130	7.620
11/1/91	13-15:00	263,625	1,157	8,385	875.0	547.4	348.3	299.8	6.100	7.690

Type of Lime: CALCITIC % Ca(OH) ₂ = 96.07 % Mg(OH) ₂ = 0.00		LS-IN	LS-CONC	FG-IN	FG-OUT	Z-AL	X-SO ₂	X-NO _x	%SO ₂	%NO _x
		Lime Slurry Feedrate	Lime Slurry Concent'n	Calculated Flue Gas In	Calculated Flue Gas Out	Calculated Air Leakage	Calculated SO ₂ Absorbed From FG	Calculated NO _x Absorbed From FG	Calculated % SO ₂ Removal	Calculated % NO _x Removal
Date	Time	GPM	WT %	SCFM	SCFM	SCFM	SCFM	SCFM	%	%
10/10/91	13:15	30.0	3.4	253,180	264,596	24,596	29.0	7.7	12.65	7.92
10/11/91	13:30	30.0	5.5	261,234	291,530	23,530	34.4	8.9	15.14	8.54
10/14/91	14:15	30.0	8.0	245,320	277,541	25,541	33.8	13.3	15.46	12.83
10/15/91	10:30	30.0	12.3	248,451	278,045	23,045	44.7	6.3	20.04	6.77
10/15/91	14:45	30.0	14.5	248,501	282,505	27,505	35.1	3.0	15.09	3.24
10/16/91	15:35	32.5	8.8	254,991	291,520	29,520	37.0	6.6	16.21	6.60
10/22/91	12-15:00	34.0	9.4	257,780	298,098	33,098	46.6	9.4	19.44	9.08
10/23/91	11-15:45	37.0	5.2	258,908	302,033	35,033	40.1	10.8	16.64	10.65
10/24/91	12-16:00	40.0	5.1	258,593	300,630	33,630	50.9	36.4	21.90	28.77
10/28/91	11-14:45	40.0	8.5	258,229	300,480	33,980	58.2	15.8	24.91	14.51
10/29/91	11-15:55	40.0	11.1	249,490	289,604	32,004	69.4	6.1	31.68	6.91
10/30/91	13-16:45	46.0	4.9	253,806	296,763	33,734	50.3	6.3	21.60	6.97
10/31/91	13-16:00	49.0	2.2	254,546	296,588	32,088	39.9	-11.2	18.22	-13.98
11/1/91	13-15:00	49.0	5.5	253,831	297,692	34,067	59.1	-0.8	26.63	-0.96

Type of Lime: CALCITIC % Ca(OH) ₂ = 96.07 % Mg(OH) ₂ = 0.00		LIME SLURRY GRAVITY, PURITY AND ALKALI					ACID GAS REMOVED			% UTIL'N
		Lime Slurry Specific Gravity	Lime Purity	Calculated Ca(OH) ₂ Content	Calculated Mg(OH) ₂ Content	Calculated Total Alkali	Calculated SO ₂ Absorbed From FG	Calculated NO _x Absorbed From FG	Calculated Total Acid Gas Absorbed	Calculated Total Alkali Utilization
Date	Time	Sp. Gr.	% Ca(OH) ₂	Lb Mol/Min	Lb Mol/Min	Lb Mol/Min	Lb Mol/Min	Lb Mol/Min	Lb Mol/Min	%
10/10/91	13:15	1.0180	96.1	0.1121	0.0000	0.1121	0.0764	0.0202	0.0967	77.20
10/11/91	13:30	1.0300	96.1	0.1835	0.0000	0.1835	0.0905	0.0235	0.1140	55.74
10/14/91	14:15	1.0435	96.1	0.2704	0.0000	0.2704	0.0890	0.0352	0.1242	39.43
10/15/91	10:30	1.0630	96.1	0.4235	0.0000	0.4235	0.1179	0.0167	0.1346	29.82
10/15/91	14:45	1.0700	96.1	0.5026	0.0000	0.5026	0.0924	0.0078	0.1002	19.16
10/16/91	15:35	1.0420	96.1	0.3218	0.0000	0.3218	0.0974	0.0175	0.1148	32.97
10/22/91	12-15:00	1.0460	96.1	0.3613	0.0000	0.3613	0.1229	0.0249	0.1478	37.45
10/23/91	11-15:45	1.0250	96.1	0.2109	0.0000	0.2109	0.1056	0.0285	0.1340	56.80
10/24/91	12-16:00	1.0270	96.1	0.2280	0.0000	0.2280	0.1341	0.0958	0.2299	79.84
10/28/91	11-14:45	1.0440	96.1	0.3833	0.0000	0.3833	0.1532	0.0417	0.1949	45.42
10/29/91	11-15:55	1.0548	96.1	0.5056	0.0000	0.5056	0.1829	0.0161	0.1990	37.76
10/30/91	13-16:45	1.0240	96.1	0.2492	0.0000	0.2492	0.1327	0.0166	0.1492	56.56
10/31/91	13-16:00	1.0110	96.1	0.1177	0.0000	0.1177	0.1051	-0.0295	0.1051	89.34
11/1/91	13-15:00	1.0283	96.1	0.2992	0.0000	0.2992	0.1558	-0.0022	0.1558	52.09

Estimating procedures and the mass balance equations for determining the estimates of SO₂ and NO_x removal and percent lime utilization are included in the Volume II, Appendix C, Section 5.

The Table 3-4 shows the CZD activity summary for October 1991 with lime slurry injection factorial tests.

The daily test data for in-duct lime slurry injection for the month of October are included in Volume II, Appendix C, Section 3.

3.3.3 Base Line Testing

Tests have been conducted to establish a baseline against which impacts of the CZD project activities can be compared. Testing has been done for particulates, PM₁₀, and fly ash.

Particulates

The level of particulates at the inlets and outlets of both of unit 15's second stage ESPs were measured by Clean Air Engineering on June 25 and 26, 1991. Levels of PM₁₀ were measured at the outlet of the test duct's ESP on June 27, 1991. The results of this testing are in Volume II, Appendix C, Section 6A.

Fuel

Simultaneous with the particulate testing conducted by CAE, Penelec conducted sampling of the incoming coal. The coal was analyzed for moisture, ash, carbon, hydrogen, oxygen, nitrogen, and sulfur. The results of the analyses and analyses of the amount of coal burned and resulting ash during September 1991 are in Volume II, Appendix C, Section 6B.

Trace Metals/Fly Ash

Simultaneous with the particulate testing conducted by CAE, Penelec collected samples of fly ash from both second stage ESPs on Unit 15. The results of the chemical analyses (total analysis and leachate analysis of inorganics) of fly ash samples are presented in Volume II, Appendix C, Section 6C.

3.3.4 Problems/Issues

- Lime injection efforts have been hampered by continuing problems with the temperature monitoring and recording system. An in-depth study, with measurement and analysis of the existing plant electrical system and grounds, will be started. In the interim, efforts are being concentrated on stabilizing the operation of the temperature recorders so that lime injection testing can continue.

Table 3-4
Lime Slurry Injection Factorial Tests
CZD Activity Summary for October 1991

Date	Duration of Lime Slurry Injection (Hours)	Lime Slurry Injection		Hydrated Calcinic Lime			SO ₂ Concentration			% Stack Opacity		Comments
		GPM	Total Gallons	% Slurry Conc.	Lime Consumption (Lbs)	% Lime Utilization	Inlet ppm	Outlet ppm	% SO ₂ Removal	Before Lime Injection	During Lime Injection	
10/10	1:35 Hrs	30	2,850	3.4%	822	77.2%	906 ppm	704 ppm	12.65%	10%	6%	
10/11	1:35 Hrs	30	2,850	5.5%	1,346	55.7%	869 ppm	660 ppm	15.14%	10%	8%	
10/14	3:15 Hrs	30	5,850	8.0%	4,073	39.43%	891 ppm	666 ppm	15.46%	10%	7%	
10/15	3:45 Hrs	30	6,750	12.3%	7,480	29.82%	899 ppm	642 ppm	20.04%	14%	8%	
10/15	1:45 Hrs	30	3,150	14.5%	4,076	19.16^	935 ppm	698 ppm	15.09%		8%	
10/16	1:14 Hrs	32.5	2,437	8.8%	1,864	32.99%	894 ppm	655 ppm	16.21%	14%	6%	
10/22	3:00 Hrs	34.0	6,120	9.4%	5,018	37.45%	931 ppm	648 ppm	19.44%			
10/23	4:00 Hrs	37.0	8,880	5.2%	3,947	56.80%	930 ppm	664 ppm	16.64%	10%	6%	
10/24	4:00 Hrs	40.0	9,600	5.1%	4,193	79.84%	899 ppm	604 ppm	21.90%	10%	6%	
10/28	3:00 Hrs	40.0	7,200	8.5%	5,328	45.42%	904 ppm	583 ppm	24.91%			
10/29	4:10 Hrs	40	10,000	11.1%	9,764	37.76%	878 ppm	517 ppm	31.68%	14%	7%	
10/30	3:00 Hrs	46	8,280	4.9%	3,465	56.56%	918 ppm	616 ppm	21.60%	12%	7%	
10/31	2:40 Hrs	49	7,840	2.2%	1,454	76.82%	860 ppm	604 ppm	18.22%			

- The design of the current nozzle lance assemblies was based on the results of previous testing at Seward Station. However, the atomizer nozzles presently in use for the test program produce an extremely fine spray, many times finer than that produced by the nozzles used in the previous test program. As a result, the large allowances for gravity effects, incorporated in the current lance assembly design, were not necessary. The current nozzle assemblies do not extend far enough into the duct. Although the lances can be rotated to change the direction of spray, they cannot be raised or lowered. As a temporary measure, the lances have been tilted to provide more coverage area. To determine the maximum possible limit of SO₂ removal, these should be replaced with lances of an improved design.
- Experience obtained to date from the current test program indicates that the parametric test program should be extended to June 30, 1992, and split into two parts:
 - Daily batch testing, as currently conducted
 - Continuous testing after the CZD system is automated and integrated with the boiler plant operation

Installation of the modifications needed for continuous operation, originally planned for the conclusion of the test program, will require a longer period for adjustment and stabilization and should be incorporated into the test program now. Testing and debugging of the automatic control system can be performed during the parametric test period, and the one-year continuous demonstration can proceed immediately after the conclusion of the continuous parametric test period on or about July 1, 1992.
- Winterization, originally included in the next phase, should be accomplished to permit continuation of the delayed test program. Without winterization testing will have to be suspended until next spring, causing additional cost and schedule overruns, and jeopardizing the continued availability of trained test personnel.
- The cost of the CZD demonstration project will increase as a result of the modified and extended parametric test program and the installation of additional equipment and instrumentation. Test operations conducted to date have indicated this equipment and instrumentation is necessary to maintain operating reliability removal efficiency and ease of operating control.

3.4 MANAGEMENT AND TRAVEL (WBS No. 1.3.10)

A progress review meeting was held at the Penelec office in Johnstown, Pennsylvania on September 11, 1991. Representatives from DOE, Bechtel, Penelec, and PEDa attended the meeting. Bechtel's test engineers discussed calibration and testing of nozzles, duct traverses, parametric water injection

testing, and future lime slurry injection plans. DOE's project manager toured the test facility after the meeting.

A technical paper was presented at the 1991 International Power Generation Conference in San Diego, California, on October 10, 1991. The paper focused on the current CZD Demonstration Program, and was coauthored by Bechtel, Penelec, and DOE/PETC.

A planning meeting was held at Bechtel's office in San Francisco, California on October 31, 1991. Project managers and key personnel from DOE, Bechtel, and Penelec attended the meeting to review current progress and develop plans and strategies to resolve the current problem areas. These areas are described under problems/issues, Section 3.3.4.

All monthly and quarterly reports required under the cooperative agreement were submitted to DOE.

Section 4

PLANNED ACTIVITIES

During the next quarter (November through January 1992) the following work is planned:

4.1 PHASE 2 - CONSTRUCTION AND START-UP

In order to allow the current test program to proceed without weather-related delays, heat tracing and insulation of process piping and construction of weather enclosures must take place in November.

All calculations and data reduction will continue to be performed manually until the existing electrical and instrumentation problems are resolved and the Bailey Infi 90 data acquisition, recording, and analysis system is available.

4.2 PHASE 3 - OPERATION AND DISPOSITION

Factorial in-duct lime slurry injection tests will continue with pressure-hydrated dolomitic lime (Type S lime) and with fresh slaked calcitic lime.

To determine the effect on stack opacity during a longer period of in-duct lime slurry injection, we intend to run a continuous test for 5 days, 24 hours per day.

A revised schedule for the parametric test program, showing the originally planned dates is shown below:

PARAMETRIC TEST PROGRAM

Original and Current Schedules

		June				July				August				September				October			November				December						
		7	14	21	28	5	12	19	26	2	9	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22	29	6	13	20	27
Calibration of atomizing nozzles, duct velocity traverses, final leak checks	Original Plan																														
	Current Plan																														
Factorial water tests in flue gas duct	Original Plan																														
	Current Plan																														
Factorial dolomitic lime injection tests	Original Plan																														
	Current Plan																														
Factorial calcitic lime injection tests	Original Plan																														
	Current Plan																														

The current plan is based on working some overtime hours and assumes no major boiler outages or equipment failures.

4.3 PHASE 3 - PROJECT MANAGEMENT

As results become available from the parametric test program, a Project Evaluation Report and Continuation Application will be prepared to permit their timely submittal.

Appendix A

DESCRIPTION OF PROJECT AND WORK BREAKDOWN STRUCTURE

A.1 PROJECT DESCRIPTION

To accomplish the objectives of this project, the test program contains two distinct periods:

- The first period, of six months duration, includes daily factorial runs to test different reagents, atomizers, additives, and slurry concentrations.
- The second period, of one year duration, will demonstrate the performance of the CZD system on a continuous basis under actual power plant operating conditions.

A detailed description of the Work Breakdown Structure for this project, as shown in Figure A-1, is given in subsection A.2. The work is scheduled to be accomplished in three phases as follows:

- Phase 1 work was completed on January 31, 1991. During this phase, Bechtel developed a process design, P&IDs, and performed detailed engineering for a new extended duct to be used in the CZD demonstration in Unit 15 at Penelec's Seward Station. Bechtel wrote all the specifications for equipment and instruments, and started procurement activities. Interface with the appropriate environmental agencies was accomplished through Penelec, with Bechtel providing assistance as needed.
- Phase 2 work was substantially completed by July 31, 1991. This phase included equipment acquisition and installation, facility construction, and start-up operations. Bechtel completed procurement of the equipment, instruments, materials, and fabrication of the new long duct. Penelec performed construction and installation of these items in accordance with specifications prepared by Bechtel. At completion of construction, using Penelec operating and maintenance personnel, Bechtel trained the operators, started all major elements of the CZD system, and verified that the installation and control system functioned according to requirements. During this phase, the installation of equipment and instrumentation was limited to that necessary for parametric testing to be accomplished in Phase 3.
- Phase 3 work will be conducted in two parts. Parametric testing, Phase 3a, was scheduled for the period from June 3, 1991 through

November 29, 1991, but the start was delayed until early August. During this period, Bechtel planned to carry out a parametric test program to optimize the performance of the CZD process. The test program is designed to develop operating conditions that will achieve high reliability and low cost operation. Phase 3b is scheduled for December 2, 1991 to July 1, 1993, to complete this demonstration project. Based on the results of the parametric test program, Bechtel will complete additional design, procurement, installation, and facility construction as necessary to permit a one-year continuous demonstration. The CZD system will be fully instrumented and integrated with the operation of Penelec's Unit 15. The goal will be to demonstrate the performance of the CZD process for SO₂ and NO_x removal without significantly affecting either boiler operation or plant particulate emission. Using Penelec operating and maintenance personnel, Bechtel will train the operators, start up, and operate the CZD system. Bechtel will supervise the one-year continuous demonstration, and will carry out various performance tests, data acquisition, and chemical analyses. After the demonstration is completed, the system may remain in operation or the test apparatus may be dismantled and the site restored to its former condition, depending on Penelec's wishes. In either case, the new long straight duct will remain in operation.

To promote the dissemination of technical information to industry during the CZD demonstration, technical papers will be presented at various conferences. These papers will provide non-proprietary technical and economic data, results and conclusions. The technical papers will also be made available for publication in appropriate journals. Representatives of the utilities will be invited to visit the demonstration site to learn first hand how the CZD process handles SO₂ and NO_x removal from utility flue gas operations.

Figure A-1 Work Breakdown Structure (WBS) Diagram

A.2 WORK BREAKDOWN STRUCTURE DESCRIPTION

The following tasks will be performed during the three phases of the project to demonstrate the cost effective control of SO₂ and NO_x emissions from the pre-NSPS coal-fired utility boiler No. 15 at Penelec's Seward Station:

Phase 1: Design and Permitting

WBS No. 1.1.2 Design and Procurement

- Prepare process flow diagrams for each of the two periods, including material balances and stream properties. Prepare technical specifications for process equipment.
- Prepare detailed designs for the fabrication of the duct extension and its associated construction and installation.
- Prepare site-specific detailed designs for installation of the compressed air system, lime feed system, and atomizers with their related headers and distribution piping, including instruments and controls.
- Prepare technical specifications for procurement of required support equipment, and its associated construction and installation.
- Issue bids for equipment with long delivery times.

WBS No.1.1.3 Management and Travel

- Project Management. Provide overall management of the work required to complete this phase, including coordination with Penelec and the groups providing project financial assistance. Bechtel's project management plan includes provisions for meetings with the DOE and formal reviews of project work, as well as provisions for submitting reports in accordance with the Federal Assistance Reporting Checklist, Attachment C.
- Travel. Bechtel travel includes project management travel to the Penelec site and to DOE's offices for meetings, and travel by the project engineer and other members of the project team as required to complete the task activities. All travel and subsistence to be in accordance with Government regulations.

Phase 2: Construction and Start-up

WBS No. 1.2.1 Equipment Acquisition and Installation

- Procure air compressors and electric power supply.
- Procure atomizers.
- Procure instruments and controls.
- Procure lime feed system.

- Procure lime transfer system.
- Provide assistance to Penelec for installation of all process and support equipment, including drawings, specifications, design packages for bidding, and other related design information.

WBS No. 1.2.2 Facility Construction

- Approve shop drawings for fabrication of duct extension.
- Provide site engineering support and related assistance to Penelec as required for quality and schedule control.

WBS No. 1.2.3 Start-up (Checkout) and Operator Training for Parametric Testing

- Provide start-up engineer to supervise commissioning of all CZD components and systems.
- Train Penelec's operators to run the CZD system and perform the tasks required to conduct parametric testing.
- Establish procedures for coordination of test operations with Penelec's plant management and operations personnel.
- Finalize all elements of Test Plan.

WBS No. 1.2.4 Construction Management

- Provide construction management support to Penelec as requested. Penelec will have prime control and responsibility for all construction activities at Seward Station.

WBS No. 1.2.5 Management and Travel

- Project Management. Provide overall management of the work required to complete this phase, including coordination with Penelec and the groups providing project financial assistance. Plan and conduct meetings with the DOE and the project team for review of project work. Submit reports in accordance with the Federal Assistance Reporting Checklist, Attachment C.
- Travel. Bechtel travel includes project management travel to the Penelec site and to DOE's offices for meetings, and travel by the project engineer and other members of the project team as required to complete the task activities. All travel and subsistence to be in accordance with Government regulations.

Phase 3: Operation and Disposition

WBS No. 1.3.1 Lime Procurement

- Procure all types of lime and other reagents required to conduct parametric and continuous (one-year) test programs.

WBS No. 1.3.2 CZD Parametric Testing

- Perform wind tunnel tests on atomizers at the University of California at Davis to determine performance characteristics. Select atomizers to be used in the parametric test program.
- Evaluate performance of electrostatic precipitators (ESPs) during parametric tests. Consult with ESP experts, if necessary, to improve performance.
- Evaluate effects of process variables on emission control performance.
- Determine operating conditions for optimum overall performance.
- Evaluate effects of using alternative coals and reagents:
 - High and medium sulfur coals
 - Alternate reagents including pressure-hydrated dolomitic lime, hydrated calcitic lime, and fresh slaked calcitic lime.

WBS No. 1.3.3 Completion of Design, Procurement and Installation

- Based on the results of the parametric tests, complete the design packages and procure all process equipment needed to completely automate and integrate the operation of the CZD system with boiler No. 15 at Seward Station.
- Procure all instruments and controls needed for continuous operation, monitoring, and data collection.

WBS No. 1.3.4 Completion of Facility Construction

- Install facilities for lime unloading and storage to support the increased capacity required for continuous operation of the CZD system.
- Insulate piping and provide weather protection and enclosures as required to permit continuous, all-year operation of the CZD system.
- Provide construction management support to Penelec as requested. Penelec will have prime control and responsibility for all construction activities at Seward Station.

WBS No. 1.3.5 Start-up (Checkout) and Operator Training for Continuous Operation

- Provide start-up engineer to supervise commissioning of all new CZD components and systems.
- Train Penelec's operators to run the CZD system and perform the tasks required to conduct the one-year continuous demonstration.

- Establish procedures for coordination of data collection and reduction with Penelec's plant management and operations personnel.

WBS No. 1.3.6 CZD Demonstration with Continuous Operation

- Operate the CZD system under optimized conditions for one year completely integrated with the power plant operation.
- Measure emission control system performance:
 - SO₂ and NO_x performance tests
 - ESP performance tests
 - ESP performance improvements, if required
 - Chemical analysis of solid wastes
 - Continuous data recording and acquisition
- Determine power plant impacts.

WBS No. 1.3.7 Duct and Hopper Cleaning

- Perform periodic inspection and cleaning, if necessary, during intervals when the boiler is not operating to determine the long-term extent of duct fouling resulting from CZD system operation.

WBS No. 1.3.8 Data Evaluation and Reporting

- Correlate and evaluate all data collected during the entire CZD test program, including parametric tests as well as continuous operation.
- Summarize key data and test results:
 - Inlet and outlet concentration of SO₂, NO_x, and oxygen
 - Amount of lime used and lime utilization
 - Variation in flue gas temperature during lime slurry injection
 - Variation in ESP recorded data
 - Variation in percent opacity at the stack
 - Lime deposition on duct surfaces
- Use technological, economic, environmental, and operating evaluations from the demonstration project to prepare Demonstration Test Reports and a Technology Performance and Economic Evaluation Report.

WBS No. 1.3.9 Disposition

- Disposition of the CZD system equipment installation:

- The new long straight duct will remain in operation.
- The disposition of all other equipment (continued operation or removal and storage) will be decided by Penelec.

WBS No. 1.3.10 Management and Travel

- Project Management. Provide overall management of the work required to complete this phase, including coordination with Penelec and the groups providing project financial assistance. Plan and conduct meetings with the DOE and the project team for review of project work. Submit reports in accordance with the Federal Assistance Reporting Checklist, Attachment C.
- Travel. Bechtel travel includes project management travel to the Penelec site and to DOE's offices for meetings, and travel by the project engineer and other members of the project team as required to complete the task activities. All travel and subsistence to be in accordance with Government regulations.

Appendix B

REPORT DISTRIBUTION LIST

The number in parentheses () indicates the number of copies submitted.

U.S. Department of Energy - PETC

Mr. Arthur L. Baldwin (2)
PETC Technical Project Manager
Mail Stop 920-L
U.S. Department of Energy / PETC
P.O. Box 10940
Pittsburgh, PA 15236

Mr. Martin J. Byrnes (1)
Contract Specialist
AD-21, Mail Stop 921-165
U.S. Department of Energy / PETC
P.O. Box 10940
Pittsburgh, PA 15236

Dr. C. Lowell Miller (1)
Associate Deputy Assistant
FE-22, 3E-042, Forrestal
U.S. Department of Energy
Washington, D.C. 20585

Mr. Robert Fischer (1)
Office of Patent Counsel
U.S. Department of Energy
9800 South Cass Avenue
Argonne, IL 60439

Office of Technology Transfer (3)
Mail Stop 58-MEZZ
U.S. Department of Energy / PETC
P.O. Box 10940
Pittsburgh, PA 15236

Dr. S. N. Roger Rao (1)
Burns and Roe Technical Group Manager
P.O. Box 18288
Pittsburgh, PA 15236

Mr. Larry M. Joseph (1)
HQ DOE Program Manager
FE-22, 3E-042, Forrestal
U.S. Department of Energy
Washington, D.C. 20585

Pennsylvania Electric Company

Mr. S. T. Higgins (1)
Project Manager
Pennsylvania Electric Company
1001 Broad Street
Johnstown, PA 15907

Mr. J.A. Seebacher (1)
Manager, Fuels Contracts and Planning
Pennsylvania Electric Company
1001 Broad Street
Johnstown, PA 15907

Pennsylvania Energy Development Authority

Mr. Dane C. Bickley (1)
Director
Pennsylvania Energy Development Authority
116 Pine Street, Second Floor
Harrisburg, Pennsylvania 17101-1227

New York State Electric & Gas Corporation

Mr. L. C. Rittenhouse (1)
Manager - Homer City Operations
New York State Electric & Gas Corporation
Homer City Power Plant
P.O. Box 29
Homer City, Pennsylvania 15748

Rockwell Lime Company

Mr. Joseph H. Brisch (1)
Sales Manager
Rockwell Lime Company
4223 Rockwood Road
Manitowoc, Wisconsin 54220-9619

END

**DATE
FILMED**

9 / 24 / 92