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INTEGRATED DRY NO_x/SO₂ EMISSIONS CONTROL SYSTEM

QUARTERLY REPORT NO. 2

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TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
<u>DISCLAIMER</u>	1
1.0 EXECUTIVE SUMMARY	2
2.0 INTRODUCTION	3
3.0 PROJECT DESCRIPTION	4
3.1 BACKGROUND	4
3.2 PROCESS DESCRIPTION	4
4.0 PROJECT STATUS	7
4.1 PHASE I - ENGINEERING AND DESIGN	7
4.1.1 Flyash System	7
4.1.2 Dry Injection System	7
4.1.3 Humidification System	7
4.1.4 Urea Injection System	7
4.1.5 Burners and NO _x Ports	7
4.1.6 Continuous Emissions Monitors	7
4.1.7 Distributed Control System	7
4.1.8 Project Management	7
4.1.9 Consulting	7
4.1.10 Engineering Research	7
4.2 PHASE IIA - PROCUREMENT	8
4.2.1 Flyash System	8
4.2.2 Dry Injection System	8
4.2.3 Humidification System	8
4.2.4 Urea Injection System	8
4.2.5 Burners and NO _x Ports	8
4.2.6 Continuous Emissions Monitors	8
4.2.7 Distributed Control System	8
4.3 PHASE IIB - CONSTRUCTION AND STARTUP	8
4.3.1 Flyash System	8
4.3.2 Dry Injection System	8
4.3.3 Humidification System	8

4.3.4	Urea Injection System	8
4.3.5	Burners and NO _x Ports	8
4.3.6	Continuous Emissions Monitors	8
4.3.7	Distributed Control System	8
4.3.8	Project Management	8
4.3.9	Consulting	8
4.3.10	Construction Management	8
4.3.11	Engineering Research	8
4.3.12	Operations and Maintenance	8
5.0	PLANNED ACTIVITIES	9
6.0	SUMMARY	10
7.0	REPORT DISTRIBUTION	11

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1.0 EXECUTIVE SUMMARY

This Quarterly Report summarizes the Integrated Dry NO_x/SO₂ Emissions Control System Project (DOE Agreement No. DE-FC22-91PC90550) progress for the months of April, May and June, 1991.

Public Service Company of Colorado (PSCC) activities focused on completing the project management database, generating the necessary monthly reports for the DOE reporting requirements, and continuing the efforts for formalizing the agreements with the other project participants. PSCC continued efforts on design of the dry injection system and finalizing the site layout.

During this period, PSCC and Stone and Webster Engineering Corp. (SWEC) completed the efforts to bid and award the order for the distributed control system, and proceed with the detailed engineering for the controls. Engineering for the power and wiring began and progressed.

Babcock & Wilcox continued with the engineering and equipment procurement for the low NO_x burners, the NO_x ports and the humidification system.

Noell, Inc. continued with engineering and material procurement on the urea system.

PSCC hosted a formal project kickoff ceremony at the Arapahoe Plant site on May 21, 1991.

2.0 INTRODUCTION

As per the DOE Cooperative Agreement No. DE-FC22-91PC90550 dated March 11, 1991, Public Service Company of Colorado has prepared the following quarterly report for Phases I, IIA, and IIB of the Integrated Dry NO_x/SO₂ Emissions Control System Project. This project includes Low NO_x Burners with post firing air injection, humidification, and dry sorbent injection. This quarterly report covers the quarterly period April, May, and June, 1991. This report covers project activities for the second three months period of the project.

The subject of this report is the project progress during the quarter for Phase I - Engineering and Design, Phase IIA - Procurement, and Phase IIB - Construction and Startup.

Under Phase I, the engineering work continued on the overall project layout, and detailed design of the burners and dry sorbent injection system. Project Management activities consisted of completing the database and completion of the software development for generating the monthly reporting requirements reports.

Under Phase IIA, progress of the engineering work allowed purchasing activities to start, with the purchase of several major pieces of equipment and systems.

Under Phase IIB, there was no activity.

3.0 PROJECT DESCRIPTION

3.1 BACKGROUND

This project's goal is to demonstrate the removal up to 70% of the NO_x and 70% of the SO_2 emissions from coal fired utility boilers. It will establish an alternative emissions control technology integrating a combination of several processes, while minimizing capital expenditures and limiting waste production to dry solids that are handled with convention ash removal equipment. These processes include low- NO_x burners and urea injection for NO_x control, sodium- or calcium-based sorbent injection for SO_2 control, and flue gas humidification to enhance the reactivity of the SO_2 control compound.

The low NO_x burners reduce NO_x formation by a combination coal/air combustion staging and the use of air ports. Urea injection downstream of the burners react chemically with NO_x to form nitrogen and water.

Sodium- and calcium-based reagents react with the SO_2 in the flue gas to form sulfites and sulfates, lowering the emissions of SO_2 . Humidification of the flue gas increases the reactivity of the calcium reactants. The solid reacted sorbent is removed with the flyash in the existing fabric filter.

Sodium based injection systems can convert nitrogen oxide (NO) to nitrogen dioxide (NO_2) which is one form of NO_x , and is visible in the stack plume under certain conditions. Ammonia, from the urea injection, reduces the NO_2 concentration by reacting with the NO_2 . Thus, system integration will alleviate a potential undesirable side effect of SO_2 removal.

The demonstration program is directed at down-fired boilers, but the process can be utilized on other types of boilers. This project will be the first U. S. application of low- NO_x burners to a down-fired boiler.

The project objectives also include demonstrating the cost effectiveness of the process and demonstrating that the process has no negative effects on normal boiler operation and does not create any other unwanted releases of gaseous or solid emissions.

3.2 PROCESS DESCRIPTION

The Integrated Dry NO_x/SO_2 Emissions Control System is a multi-part process in which low- NO_x burners, NO_x ports, and urea injection is used to control NO_x . Sodium-based sorbent injection or calcium-based sorbent injection, combined with in-duct humidification is used for SO_2 removal.

B&W XCL Burner

NO_x , formed during the combustion of fossil fuels consists of NO_x formed from fuel bound nitrogen, thermal NO_x , and prompt NO_x . NO_x formed from fuel bound nitrogen results from the oxidation of nitrogen which is bonded to the fuel molecules. Thermal NO_x forms when nitrogen in the combustion air dissociates and oxidizes at flame temperatures in excess of 2800°F. Prompt NO_x forms during the combustion process when hydrocarbon radicals dissociate atmospheric nitrogen, which then oxidizes.

The B&W XCL burner achieves increased NO_x reduction effectiveness by incorporating fuel staging along with air staging. Most of low- NO_x burners reduce NO_x by the use of air staging. Air staging reduces the amount of combustion air during the early stages of combustion. Fuel staging involves the introduction of the fuel downstream of the flame under fuel-rich conditions, causing hydrocarbon radicals to be generated. These radicals reduce NO_x levels. This is accomplished by the coal nozzle/flame stabilizing ring design of the

burner. In addition, combustion air is accurately measured and regulated to each burner to provide balanced air and fuel distribution for optimum NO_x reduction and combustion efficiency. Further, the burner assembly is equipped with adjustable burner vanes to provide swirl for flame stabilization and fuel/air mixing.

NO_x Ports

NO_x ports are used in conjunction with low-NO_x burners to increase the effectiveness of air staging. NO_x ports provide the final air necessary to ensure complete combustion. Conventional single jet NO_x ports are not capable of providing adequate mixing across the entire furnace. The B&W dual zone NO_x ports, however, incorporate a central zone which produces an air jet that penetrates across the furnace and a separated outer zone that diverts and disperses the air in the area of the furnace near the NO_x port. The central zone is provided with a manual air control disk for flow control and the outer zone incorporates manually adjustable spin vanes for air swirl control.

The combined use of the B&W XCL burners and dual zone NO_x ports is expected to reduce NO_x emissions by up to 70%.

Urea Injection

NO_x reduction in utility boilers can also be accomplished by injecting urea into the furnace. The urea reacts with the NO_x and oxygen in the gases and forms nitrogen, carbon dioxide, and water. A urea injection system is capable of removing 40% to 50% of the remaining NO_x from the combustion process.

The optimum urea injection reaction temperature range is between 1700°F and 1900°F. At lower temperatures, side reactions can occur, resulting in the undesirable formation of ammonia. At higher temperatures, additional NO_x is formed. Chemical additives can be injected with the urea to widen the optimum temperature range and minimize the formation of ammonia.

The urea is generally injected into the boiler as an aqueous solution through atomizers. The atomizing medium can be either air or steam. The urea and any additive are stored as a liquid and pumped into the injection atomizers.

Dry Reagent SO₂ Removal System

The dry reagent injection system consists of equipment for storing, conveying, pulverizing, and injecting sodium based products into the flue gas between the air heater and the particulate removal equipment or calcium products between the economizer and the air heater. The SO₂ formed during the combustion reacts with the sodium- or calcium-based reagents to form sulfates and sulfites. These reaction products are collected in the particulate removal equipment together with the fly ash and the unreacted reagent and removed for disposal. The system is expected to remove up to 70% SO₂ while using sodium based products and maintaining high sorbent utilization.

Dry sodium-based reagent injection systems reduce SO₂ emissions. However, NO₂ formation has been observed in some applications. NO₂ is red/brown gas. A visible plume may form as the NO₂ in flue gas exits the stack. Previous tests have shown that ammonia slip from the urea injection system reduces the formation of NO₂, while removing the ammonia which would otherwise exit the stack.

In certain areas of the country, it may be more economically advantageous to use calcium-based reagents, rather than sodium-based reagents, for SO₂ removal. SO₂ removal using calcium-based reagents involves the dry injection of the reagent into the furnace at a point where the flue gas temperature is approximately 1000°F. Calcium-based materials can also be injected into the flue gas ductwork downstream of the air heater, but at reduced SO₂ removal effectiveness.

Humidification

In addition to the selection of the proper injection point, the effectiveness of the calcium-based reagent in reducing SO_2 emissions can be increased by flue gas humidification. Flue gas conditioning by humidification involves injecting water into the flue gas stream downstream of the air heater and upstream of any particulate removal equipment. The water is injected into the duct by dual fluid atomizers which produce a fine spray that can be directed downstream and away from the duct walls. The subsequent evaporation causes the flue gas to cool, thereby decreasing its volumetric flow rate and increasing its absolute humidity. It is important that the water be injected in such a way as to prevent it from wetting the duct walls and to ensure complete evaporation before the gas enters the particulate removal equipment or contacts the duct turning vanes. Since calcium-based reagents are not as reactive as sodium-based reagents, the presence of water in the flue gas, which contains unreacted reagent, provides for additional SO_2 removal. Up to 50% SO_2 removal is expected when calcium reagents are used in conjunction with flue gas humidification.

4.0 PROJECT STATUS

This project Quarterly Report Number 2 covers the quarterly period for April, May, and June, 1991. This report discusses progress on a task basis for each of Phases I, IIA and IIB.

4.1 PHASE I - ENGINEERING AND DESIGN

4.1.1 Flyash System: PSCC started the general arrangement drawing for the dry ash system silo addition.

4.1.2 Dry Injection System: PSCC started the general arrangement and the P&ID drawings for the sorbent injection system, and tested an Entoleter mill for the dry injection system, which shows promise to simplify the system design. PSCC completed the preliminary duct injection port layout drawings.

PSCC also completed a survey to determine that all locations are above the flood plane.

4.1.3 Humidification System: Babcock & Wilcox completed preliminary P&ID's and instrument lists for the humidification system. PSCC reviewed the system drawings.

4.1.4 Urea Injection System: PSCC determined the air requirements for specifying the air compressors and the compressed air system. Noell, Inc., issued the preliminary P&ID, general arrangement, and building layout drawings for the urea injection system for comment. Noell Inc. continued work on the urea system design.

4.1.5 Burners and NO_x Ports: B&W developed the mathematical model to determine the location and size of the NO_x ports, and completed the preliminary general arrangement drawings for the ductwork and burner placement. They also completed a site walk-down to finalize the general arrangement drawings. The burner and NO_x port general arrangement drawings were issued to PSCC on May 20, 1991 for approval.

B&W completed the main gas piping design and continued the design work on the humidification system. PSCC advised B&W to provide ceramic elbows on the coal pipes at the burners to lessen pipe wear.

Babcock & Wilcox completed NO_x port design work, air monitor specifications, draft calculations, F.D. fan review, and stress analysis on tie-in loads. They also ran tests on the prototype vertical XLC burner with satisfactory results. PSCC continues work on drawing review for the burners.

4.1.6 Continuous Emissions Monitors: No Activity.

4.1.7 Distributed Control System: PSCC started work on the control logic diagrams. Stone & Webster and PSCC completed the Distributed Control System preliminary I/O list. PSCC completed the controls building layout.

4.1.8 Project Management: PSCC continued with developing the data base and the necessary software to create the monthly reports for the reporting requirements. PSCC held a formal project kickoff ceremony at Arapahoe Station on May 21, 1991, and an informal project coordination meeting on May 20, 1991.

4.1.9 Consulting: FERCO completed the flow modeling and the temperature traverse to optimize the location of the urea injection nozzles.

4.1.10 Engineering Research: Colorado School of Mines began preliminary work on the test reactor. Work progressed on executing the contract.

4.2 PHASE IIA - PROCUREMENT

4.2.1 Flyash System: PSCC prepared and issued the bid documents for the dry ash handling system silo addition.

4.2.2 Dry Injection System: PSCC completed and issued the specification and bid documents for the reagent pulverizer. Stone & Webster prepared the specification and PSCC issued the bid documents for the common switchgear for the dry injection system, the urea injection, and the humidification air compressors. PSCC received bids for the motor for the reagent pulverizers, and the 4KV switchgear and the 480 V load centers.

4.2.3 Humidification System: No Activity.

4.2.4 Urea Injection System: Noell continued with procurement of the urea injection system equipment. PSCC purchased the air compressor. PSCC prepared the specification and issued the bid documents for the urea system air compressor motor. Noell, Inc. continues work on the urea system equipment procurement.

4.2.5 Burners and NO_x Ports: No Activity.

4.2.6 Continuous Emissions Monitors: No activity.

4.2.7 Distributed Control System: Stone & Webster transmitted the specification for the Distributed Control System to PSCC in early April. PSCC sent the Request for Quotation and Specification out for bids, and received the proposal the end of April. PSCC held a controls kickoff meeting at Arapahoe Station on May 14th and 15th to better define the control system scope and complete pricing of the distributed control system (DCS). DOE approved the sole source supply of the DCS with Westinghouse as the supplier. PSCC subsequently issued a purchase order to Westinghouse for the system. PSCC started the control building specification.

4.3 PHASE IIB - CONSTRUCTION AND STARTUP: No Activity.

- 4.3.1 Flyash System
- 4.3.2 Dry Injection System
- 4.3.3 Humidification System
- 4.3.4 Urea Injection System
- 4.3.5 Burners and NO_x Ports
- 4.3.6 Continuous Emissions Monitors
- 4.3.7 Distributed Control System
- 4.3.8 Project Management
- 4.3.9 Consulting
- 4.3.10 Construction Management
- 4.3.11 Engineering Research
- 4.3.12 Operations and Maintenance

5.0 PLANNED ACTIVITIES

The planned activities for the next quarter, July, August, and September, 1991, include the following:

1. Issue P.O.s for dry injection system pulverizers, and dry ash handling system.
2. B&W will issue the final performance job report, the flow modeling report, complete the initial issue of burner and NO_x port drawings, and develop the erection schedule.
3. Prepare and issue bid packages for air compressors, motor control centers, the remaining dry injection system major equipment, and transmitters.
4. Begin detailed electrical design and control system logic configuration in support of DCS.
5. Issue bids and purchase urea system building and control building.
6. Design building foundations, issue drawings, and start building foundation construction.
7. Complete urea system design
8. Complete site clearing demolition work.
9. Complete environmental monitoring plan draft.

6.0 SUMMARY

Phase I - Engineering and Design: Engineering and design started on all aspects of the project, with emphasis on the burners and NO_x ports and the humidification system (B&W), the urea system (Noell, Inc.), the dry injection system (PSCC), and the control system (PSCC and SWEC). Drawing issue and approval started with preliminary issue of several general arrangement and P&ID drawings.

Phase IIA - Procurement: Equipment procurement started with specification preparation and bidding of equipment for the urea system and the electrical and controls systems.

Phase IIB - Construction and Startup: No activity.

7.0 REPORT DISTRIBUTION

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