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INTEGRATED DRY NO_x/SO_2 EMISSIONS CONTROL SYSTEM

QUARTERLY REPORT NO. 3

FOR PERIOD - JULY 1 - SEPTEMBER 30, 1991

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DOE COOPERATIVE AGREEMENT NO. DE-FC22-91PC90550

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1.0 EXECUTIVE SUMMARY

This Quarterly Report summarizes the Integrated Dry NO_x/SO_2 Emissions Control System Project (DOE Agreement No. DE-FC22-91PC90550) progress for the months of July, August and September, 1991.

Public Service Company of Colorado (PSCC) activities focused on detailed engineering and on vendor drawing review. PSCC continued efforts on the dry injection system design.

During this period, PSCC and Stone and Webster Engineering Corp. (SWEC) continues with the detailed engineering for the control and electrical systems.

Babcock & Wilcox continues 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.

2.0 INTRODUCTION

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/SO_2 Emissions Control System Project. This project includes Low NO_x Burners with NO_x (post firing air injection), humidification, and dry sorbent injection. This quarterly report covers the quarterly period July, August, and September, 1991. This report covers project activities for the third three month 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 the continuation of scheduling and reporting activities and participating in DOE's project management review process with Grant-Thornton.

Under Phase IIA, purchasing activities of materials and equipment for the major systems continue.

Under Phase IIB, Construction activities started August 16, 1991 with demolition and foundation work. Construction emphasis is on the urea system.

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 conventional ash removal equipment. These processes include low-NO_x burners, NO_x ports 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 NO_x ports. Urea injection downstream of the burners reacts 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 system 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.

<u>B&W XCL Burner</u>

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, incorporates 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 SO_2 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 SO_2 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% SO_2 while using sodium based products and maintaining high sorbent utilization.

Dry sodium based reagent injection systems reduce SO_2 emissions. However, NO_2 formation has been observed in some applications. NO_2 is red/brown gas. A visible plume may form as the NO_2 in flue gas exits the stack. Previous tests have shown that ammonia slip from the urea injection system reduces the formation of NO_2, 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 SO_2 removal. SO_2 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 SO_2 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 reagent 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 3 covers the quarterly period for July, August, and September, 1991. This report discusses progress on a task basis for Phase I, IIA and IIB.

4.1 PHASE I - ENGINEERING AND DESIGN

4.1.1 Flyash System: PSCC has received drawings from the supplier.

4.1.2 Dry Injection System: The system layout and the P&ID are completed. Work continues on the general arrangement and detailed system design.

4.1.3 Humidification System: Babcock & Wilcox issued the flow modeling report for the NO_x port locations, performed testing to determine a gas flow balance within the duct, and sent a copy of the data to PSCC. Babcock & Wilcox completed the preliminary control philosophy and system description. Babcock & Wilcox visited the plant site to verify design work and to assist their office efforts in pre-outage planning and site preparations. They issued drawings for review, comment, or approval for the humidifier rapper system, system P&ID's, valve tag information, and system logic. They also sent PSCC the system resistance curve for the system piping.

4.1.4 Urea Injection System: Stone & Webster completed preparation of the air compressor specification, and the MCC specification, and started work on the instrument transmitter specification. They also completed the bid evaluation and submitted a purchase recommendation to PSCC on the 480 V switchgear and the 4KV switchgear. Work began on the electrical one-line diagrams.

Stone & Webster completed efforts on the electrical construction specification, and on the evaluation of the motor control center bids. They also issued the electrical drawings for the urea system. The MCC schematic and wiring diagrams for the urea system, the 480 V MCC specification and the preliminary cable list for the urea system are all complete.

Noell, Inc. continues work on the urea system design and equipment procurement. All equipment and service purchase orders are issued, and the flow modeling and temperature testing is complete. Noell, Inc. continues work on the urea system detailed engineering and fabrication detail drawings, and some equipment fabrication. Noell's Virginia office finalized the design of the controls and instrumentation. They completed response to PSCC comments on drawings at the design review meeting on September 24, 1991.

4.1.5 Burners and NO_x Ports: Babcock & Wilcox continues work on the assembly drawings for the burners and NO_x ports. Babcock & Wilcox drawing issue continues, with the issue of burner and NO_x port drawings, burner management input/output descriptions, steel drawings, and electrical information. Designers visited the plant to verify actual field locations for equipment tie in. At PSCC's request, Babcock & Wilcox investigated the necessary modifications to the burners to eliminate the requirement for coal nozzle and gas burner cooling air.

Babcock & Wilcox built and tested a full scale air control disk to check the modifications to the burner design to accommodate the vertical arrangement.

Stone & Webster completed the burner management logic diagrams.

4.1.6 Continuous Emissions Monitors: No Activity.

4.1.7 Distributed Control System: SWEC issued the final data base for the control system to Westinghouse. SWEC began the work on the breaker control schematics and wiring diagrams, and continued with the development of the functional control logic for non-boiler systems.

4.1.8 Project Management: Grant-Thornton, DOE's contractors for the project management review visited PSCC and SWEC in Denver during the week of September 23, 1991, and visited Babcock & Wilcox in Ohio on September 30, 1991.

4.1.9 Consulting: No activity.

4.1.10 Engineering Research: Colorado School of Mines has advertised for a graduate student to work on the project. They also completed preliminary process thermodynamic calculations.

4.2 PHASE IIA - PROCUREMENT

4.2.1 Flyash System: PSCC issued purchase orders for the ash system and ash handling system modifications.

4.2.2 Dry Injection System: PSCC issued the purchase order for the reagent pulverizer, and continued purchasing activity for the remaining equipment.

4.2.3 Humidification System: Babcock & Wilcox quoted components, and issued purchase orders for humidification system equipment.

PSCC issued the bid documents for the humidification system air compressor.

4.2.4 Urea Injection System: PSCC issued purchase orders for the motor for the urea system air compressor, the 4KV switchgear, the 480 V load centers and the urea system.

Noell, Inc. completed ordering all remaining urea system equipment. Several pieces of urea system equipment arrived on site.

4.2.5 Burners and NO_x Ports: Babcock & Wilcox completed the specifications for the dampers and expansion joints, and quoted and purchased the flame scanners and the cooling air blowers.

4.2.6 Continuous Emissions Monitors: No activity.

4.2.7 Distributed Control System: PSCC issued the purchase order for the control system building.

4.3 PHASE IIB - CONSTRUCTION AND STARTUP:

4.3.1 Flyash System: No activity.

4.3.2 Dry Injection System: No activity.

4.3.3 Humidification System: No activity.

4.3.4 Urea Injection System: PSCC's construction crews moved on site August 19, 1991 and started work on the underground relocations and the urea system foundation. Demolition of the existing building and foundations is complete.

4.3.5 Burners and NO_x Ports: No activity.

4.3.6 Continuous Emissions Monitors: No activity.

4.3.7 Distributed Control System: PSCC construction forces completed the foundations for the control building and has started work on the underground electrical duct banks. PSCC's building supplier began erection of the control system building.

4.3.8 Project Management: No activity.
4.3.9 Consulting: No activity.

4.3.10 Construction Management: PSCC selected its site engineer to direct site activities.

4.3.11 Engineering Research: No activity.

4.3.12 Operations and Maintenance: No activity.

5.0 PLANNED ACTIVITIES

The planned activities for the next quarter, October, November, and December, 1991, include the following:

1. PSCC will complete the necessary design for the ash system mechanical and electrical interfaces and begin construction of the ash silo foundation.

2. PSCC will complete the detailed mechanical design, continue with the electrical design, and complete major equipment purchases for the dry injection system. PSCC Construction will complete the building foundation, and the building contractor will erect the dry sodium injection building.

3. Babcock & Wilcox, PSCC and SWEC will continue with the electrical design efforts on the humidification system, and the distributed control system.

4. Construction activities will continue for the urea system.

5. Babcock & Wilcox will continue with design, procurement and manufacture the low NO_x burners and NO_x port system, and make preparations for construction activities.

6. FERCO will complete the boiler baseline tests and begin preparations for the baseline urea tests.

6.0 SUMMARY

Phase I - Engineering and Design: Engineering and design continues on all aspects of the project, with continued 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 continues with the issuance of additional general arrangement, detailed design, and P&ID drawings.

Phase IIA - Procurement: Equipment procurement continues with specification preparation and bidding of equipment for the urea system and the electrical and controls system, and the dry injection system.

Phase IIB - Construction and Startup: Construction activities started on August 19, 1991, with good progress on the equipment foundations and the urea system.

7.0 REPORT DISTRIBUTION

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