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EVALUATION OF
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CONTROL TECHNOLOGY

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Prepared by

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EVALUATION OF SIMULTANEOUS SO_2/NO_x CONTROL TECHNOLOGY

by:

Kevin R. Bruce and Walter F. Hansen
Acurex Environmental Corporation
4915 Prospectus Drive
P.O. Box 13109
Research Triangle Park, NC 27709

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EPA Project Officer: Brian K. Gullett
U.S. Environmental Protection Agency
Air and Energy Engineering Research Laboratory
Research Triangle Park, NC 27711

Prepared for:

Nalco Fuel Tech
P.O. Box 3031
Naperville, IL 60566-7031
(Under Cooperative Research and Development Agreement)
and
U.S. Environmental Protection Agency
Office of Research and Development
Washington, DC 20460

ABSTRACT

The Clean Air Act Amendments of 1990 have led to accelerated research into novel SO_2 and NO_x control technologies for coal-fired industrial boilers. One of these technologies is the combination of sorbent injection and selective non-catalytic reduction (SNCR) for simultaneous SO_2/NO_x removal. The work presented herein concentrated on characterizing several process operational parameters of this technology: injection temperature, sorbent type, and reductant/pollutant stoichiometric ratio. A slurry composed of a urea-based solution (NO_xOUT A or NO_xOUT A+)* and various Ca-based sorbents was injected at a range of temperatures and reactant/pollutant stoichiometries in a natural-gas-fired, pilot-scale reactor with doped pollutants. Up to 80 percent reduction of SO_2 and NO_x at reactant/pollutant stoichiometric ratios of 2 and 1.5, respectively, was achieved. SO_2 emission reductions from slurry injection were enhanced moderately when compared with dry sorbent injection methods, possibly caused by sorbent fracturing to smaller, more reactive particles. Emissions from NH_3 slip (unreacted nitrogen-based reducing agent) and N_2O formation were reduced in comparison with other published results, while similar NO_x reductions were obtained. Increased CO emissions, caused by the decomposition of urea, were moderate. Emissions of CO, NH_3, and N_2O for the enhanced urea solution (NO_xOUT A+) were substantially less than the levels observed during urea (NO_xOUT A) injection. The injection of the urea-based solution enhanced the SO_2 removal, probably because of the formation of $(NH_4)_2Ca(SO_4)_2 \cdot H_2O$. The results of this pilot-scale study have shown high reduction of both SO_2 and NO_x.

(*) Where used throughout this report, NO_xOUT A and NO_xOUT A+ are registered trademarks of Nalco Fuel Tech.

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The assistance of EPA Project Officer Brian K. Gullett in preparing this report is gratefully acknowledged. His contribution consisted of substantive preparation of the results, discussion, and conclusion sections, as well as providing overall guidance for the project. Additionally, the help of George R. Gillis and Frank E. Briden, of the EPA (AEERL) with equipment construction and solid material analyses, respectively, is greatly appreciated. The facilities operation, by Charles B. Courtney of Acurex Environmental Corporation, was also of great value to the success of this work. Special thanks to the Tenn Luttrell Company for providing the sorbents.

EXECUTIVE SUMMARY

The project work reported herein was initiated through a Cooperative Research and Development Agreement (CRADA) between the U.S. Environmental Protection Agency's (EPA) Air and Energy Engineering Research Laboratory (AEERL) and Nalco Fuel Tech, a commercial licensor of a urea-based reducing agent injection technology for NO_x reduction.

Experimental testing of Nalco Fuel Tech's urea-based NO_xOUT A and NO_xOUT A+ reducing agents for NO_x control, in combination with calcium-based sorbent injection for SO_2 control, was conducted from June 1991 to November 1991. Testing was performed at the EPA Environmental Research Center in Research Triangle Park, NC in a pollutant-doped, natural gas-fired furnace (14,650 W).

The project scope of work included testing furnace sorbent injection of several calcium-based sorbents to remove SO_2 from flue gas. The tested sorbents came from a single source of commercially prepared $Ca(OH)_2$, $CaCO_3$, and CaO. A comparison of SO_2 removal efficiency was made between dry and slurry injection. The effect of $CaCO_3$ sorbent particle size was also studied.

Slurry sorbent injection was found to be superior to dry injection for SO_2 removal. Dry injection of $Ca(OH)_2$ achieved a maximum of 60 percent SO_2 removal (at a Ca/S ratio = 2), while the $Ca(OH)_2$ slurry removed 72 percent. Removal efficiency with $Ca(OH)_2$ was superior to $CaCO_3$ in both dry (43 percent) and slurry (58 percent) testing. CaO was tested in slurry form by slaking to form $Ca(OH)_2$ slurry, and compared to the commercially prepared $Ca(OH)_2$. The slaked CaO proved identical in its SO_2 removal performance to the commercially prepared $Ca(OH)_2$.

Investigation into the effect of sorbent particle size on removal efficiency showed that the increasing reactivity of the sorbent with SO_2 was inversely proportional to the sorbent particle size. After sieving the $CaCO_3$ sorbent, a significant increase in performance was observed with the finer particle size, with SO_2 capture comparable to $Ca(OH)_2$ of equivalent size for dry injection. Results from this work indicate $Ca(OH)_2$ to be superior to $CaCO_3$ under all conditions of slurry injection.

NO_xOUT A and NO_xOUT A+ reducing agents were tested over a range of injection temperatures (821-1,170 °C) to investigate the effect on NO_x removal efficiency. Additionally, the effect of varying the molar ratio of reducing agent to baseline NO_x concentration from 0.8 to 3.5 was studied. Finally, the reducing agent injection for NO_x removal was coupled with slurried sorbent injection for SO_2 removal.

Both reducing agents achieved maximum NO_x removal when injected at a temperature of about 1,100 °C. Almost no difference in the two reducing agents existed at the optimum temperature; approximately 80 percent NO_x removal was observed for both reducing agents. At temperatures higher than the optimum, NO_x removal efficiency dropped quickly. At about 1,170 °C, the reducing agents began producing NO_x, caused probably by high temperature oxidation of the NH_3 produced by urea decomposition. At temperatures lower than the optimum, NO_x removal efficiency gradually decreased. The NO_xOUT A+ yielded a wider injection temperature window; that is, NO_x removal efficiency remained higher than with NO_xOUT A as injection temperature decreased.

Varying the molar ratio of reducing agent (urea) to baseline NO_x, or N/NO_{xi}, showed that increasing N/NO_{xi} to a value of near 2 produced significant improvement in NO_x removal. Further N/NO_{xi} increases had little or no effect on removal efficiency. Comparing the two reducing agents during N/NO_{xi} variation shows no appreciable differences in behavior.

Coupling reducing agent injection with slurried sorbent injection produced some promising results. The co-injection of NO_xOUT A improved all the sorbents' performances. The effect was not as pronounced with $CaCO_3$ as that of $Ca(OH)_2$ and slaked CaO. A maximum SO_2 removal enhancement of 2-3 percent absolute was observed with $CaCO_3$, while a 10 percent absolute enhancement was observed for $Ca(OH)_2$ and slaked CaO. $CaCO_3$ slurry with the NO_xOUT A reducing agent achieved a maximum of about 60 percent SO_2 removal of approximately 1,000 °C. SO_2 removals of more than 80 percent were observed with $Ca(OH)_2$ at the same temperature. As was previously stated, the slaked CaO performed identically to the $Ca(OH)_2$.

The work mentioned above also entailed characterizing NH_3, N_2O, and CO emissions produced by injecting the reducing agent over a range of temperatures and N/NO_{xi}. Each reducing agent produced maximum NH_3 slip (unreacted nitrogen-based reducing agent) at the lower injection temperatures; around 821 °C, the amount of slip was about 140 ppm for both NO_xOUT A and NO_xOUT A+. As injection temperature increased, NH_3 slip for the NO_xOUT A decreased quickly, while slip from NO_xOUT A+ dropped off almost completely at around 875 °C. At 900-1,000 °C, slip generated by NO_xOUT A gradually decreased to a level of about 60 ppm. Throughout this temperature regime, NO_xOUT A+ produced negligible NH_3 slip (<10 ppm).

CO emissions produced by NO_xOUT A rose gradually from about 20 ppm at 800 °C to a maximum of 25 ppm at 1,100 °C. NO_xOUT A+ produced low CO at 800-1,000 °C (<10 ppm), with a maximum of 50 ppm around 1,100 °C.

N_2O production by NO_xOUT A was negligible at lower injection temperatures (approximately 25 ppm), but increased with injection temperature to a maximum of 200 ppm at approximately 1,150 °C, about 42 percent of the NO_x reduced. NO_xOUT A+ produced only moderate levels of N_2O (typically <40 ppm, less than 20 percent of the NO_x reduced) over the entire temperature range. A maximum of about 30 ppm was observed at around 1,150 °C.

Aqueous ammonia solution injection was performed to ensure that these results would be reproducible on other facilities. Available data for NO_x removal using aqueous ammonia injection showed comparable results to others' work. These data validated improvements shown by this work with both NO_xOUT solutions and suggested the applicability of these results to other facilities.

Testing of the solid waste ash/sorbent/urea mixtures indicated that ash resistivities increased to levels exceeding 10^{13} ohm-cm. This resistivity level can adversely affect electrostatic precipitator performance. However, these laboratory values were obtained at low temperatures. Resistivity values decrease at higher precipitator temperatures and typically are lower in the field than in laboratory measurements. Further work in pilot-scale precipitators would help determine whether particle collection will be adversely affected by sorbent/reducing agent injection.

SECTION 1

INTRODUCTION

Passage of the 1990 Clean Air Act Amendments (CAAA) has initiated extensive evaluation and planning for strategies to meet SO_2 and NO_x emission requirements. Furnace sorbent injection of calcium-based material for SO_2 removal is a technology that has been field tested on a number of units, achieving, for example, 63 percent SO_2 removal at a Ca/S (molar ratio) = 2 with a calcium hydroxide [Ca $(OH)_2$] sorbent and 72 percent with a surfactant-modified $Ca(OH)_2$ sorbent on a 105 MW(e) wall-fired unit.[1] Typically, lower SO_2 removals are achieved with calcium carbonate ($CaCO_3$) sorbents.

The anticipated NO_x regulations may be met, at least in part, by selective non-catalytic reduction (SNCR) which has achieved about 60 percent NO_x reduction on a 150 MW(e) coal-fired boiler at a molar ratio of reducing agent nitrogen to initial NO_x concentration (N/NO_{xi}) of 2.[2] SNCR has also been the subject of numerous laboratory and pilot-scale studies.[3,4] SNCR involves high-temperature furnace injection (800-1,100 °C) of a nitrogen-based reducing agent such as urea (NH_2CONH_2) or ammonia (NH_3), which converts NO_x to N_2 and H_2O.

Most concerns with using SNCR center around NH_3 emissions, or slip, which results from incomplete reaction of the injected reducing agent and the production of nitrous oxide (N_2O) caused by incomplete reduction of NO_x. NH_3 slip can cause ammonium bisulfate (NH_4HSO_4) formation around 300 °C and ammonium sulfate [$(NH_4)_2SO_4$] formation around 150 °C. The former can deposit upon air preheater surfaces reducing heat transfer and increasing pressure drop. It can also cause

NH_4Cl formation around 100 °C which results in a visible white plume in the stack emissions. N_2O has been implicated as a contributor to stratospheric ozone depletion and global warming, the latter because of its ability to absorb infrared radiation.[5,6]

Research has demonstrated that levels of N_2O and NH_3 emissions from various SNCR compounds are extremely sensitive to injection temperature.[7,8] Efforts to widen the applicable temperature injection window and control NH_3 slip and N_2O production through using additives have brought about some success, yet concerns remain to be addressed on the SNCR-type process.[9] Similar research on SO_2/NO_x control processes has shown considerable merit, while significant questions still remain in the industry concerning NH_3 emissions and N_2O by-product formation.[10]

To further investigate simultaneous SO_2/NO_x control by sorbent/reducing agent injection, the U.S. Environmental Protection Agency (EPA) entered into a Cooperative Research and Development Agreement (CRADA) with Nalco Fuel Tech to test NO_xOUT A and NO_xOUT A+, two commercial reducing agents produced by Nalco Fuel Tech, in conjunction with sorbent injection in AEERL's 14,650 W pilot facility. Variables of operation included injection temperature, stoichiometric ratio, and sorbent type. Emissions monitoring results for SO_2, NO_x, N_2O, CO, and NH_3 are reported.

SECTION 2

OBJECTIVES

The principal objective of this research was to demonstrate the effectiveness of simultaneous SO_2 and NO_x removal by concurrent injection of a calcium-based slurry and NO_xOUT A (or NO_xOUT A+), a urea-based reducing agent, while minimizing emissions of N_2O and NH_3. Other secondary objectives defined in the CRADA between EPA and Nalco Fuel Tech included:

- Characterizing the operating conditions for sorbent slurry injection
- Comparing the removal efficiency of dry vs. slurry injection
- Evaluating the benefit of finely ground limestones/hydrated lime
- Optimizing injecting conditions, with targets of 60 percent SO_2 removal at Ca/S = 2 and 60-70 percent NO_x reduction at an N/NO_{xi} of 2
- Comparing CO, NH_3, and N_2O emissions produced by the injection of NO_xOUT A and NO_xOUT A+ (an enhanced urea-based reducing agent) over a wide range of injection temperatures and reducing agent/NO_x stoichiometries

SECTION 3

EXPERIMENTAL

3.1 FURNACE

The Innovative Furnace Reactor (IFR) system consists of a furnace, coal or natural gas feeders, a sorbent feeding system, emissions monitoring systems, and a particulate matter sampling system.

The furnace is a refractory-lined, down-fired cylindrical combustor capable of burning a variety of fuels including coal, natural gas, and some oils. The furnace is used to simulate the gaseous combustion environment and quench rate conditions anticipated in utility and industrial boilers. The internal bore (diameter) of the furnace is 15.2 cm while the length is about 4 m. It is constructed of several stacked rolled steel rings 76.2 cm in diameter and varying between 30-60 cm high. The rings are insulated by four courses of refractory, the last of which is a hard-faced, erosion-resistant type that forms the internal bore. An illustrated cross-section of the IFR is shown in Figure 1. Various view and injection/sample ports are along the length of the reactor while fuel and combustion air are fed in at the top of the furnace and burned. Coal feed is controlled by a vibrating-hopper, screw-type feeder. The coal is loaded into the feeder hopper where it is metered into a downward facing funnel-shaped receiver. At the receiver, the coal flow is aspirated into and through a copper line and delivered to the burner. Natural gas is metered into the burner through a rotameter at a known flow and pressure. Two types of air flow are provided in the burner region; the axial and tangential air flows at the burner are fully adjustable by flow and pressure. The combustion products travel down and out of the refractory-lined sections into a water-cooled junction where they turn 90° into a sampling stack.

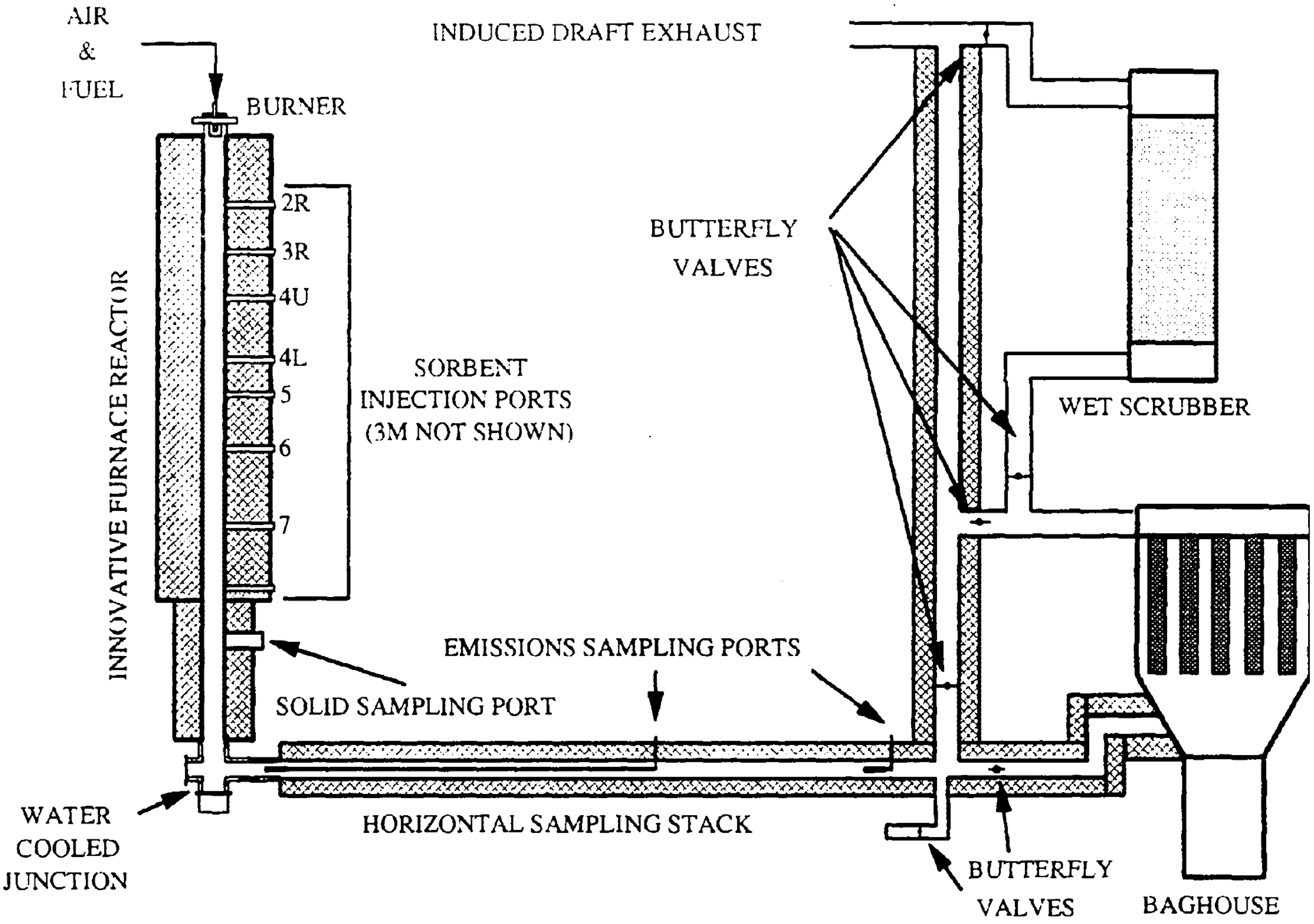


Figure 1. Schematic of Innovative Furnace Reactor system.

3.2 FURNACE OPERATION DURING NATURAL GAS FIRING

Typical set-up procedures for natural gas firing included introducing the fuel (nominally CH_4, 37.8 kJ/L) through an axial feeder tube at the burner on the top of the combustor. There were four input gas flows to the furnace: CH_4 gas, axial air, tangential air, and sorbent/slurry transport air. All gas flows were controlled through rotameters. Sorbent delivery air flows were slightly different for the two types of injection (slurry/dry). The injection lances used required different flows to establish optimum sorbent atomization/distribution.

During slurry injection, 6.47 standard L/s of total pre-combustion air was supplied to the furnace through the three previously stated air flows. Natural gas was supplied at a rate of 0.557 standard L/s to yield an air/fuel combustion stoichiometry of approximately 1.20. The distribution of air flow was 67.4 percent through the tangential air supply, 14.6 percent through the axial air, and 18.0 percent through the sorbent injection lance. The majority of the air was supplied tangentially at the burner to ensure good mixing of the doping gases.

Dry injection trials required a total air supply of 6.56 standard L/s. The natural gas flow remained the same, but the combustion stoichiometry was slightly higher. Air flow distribution was 69.7 percent through the tangential air, 14.6 percent through the axial air, and 15.7 percent through the sorbent probe.

During natural gas burns, simulation of combustion products formed during true coal burning was performed by doping the feed natural gas with known concentrations of bottled NH_3 and SO_2. The NH_3 was added to the combustion zone by mixing with the natural gas feed stream. The two gases mixed just before entering the burner. The NH_3 was quantitatively oxidized to NO_x during combustion. SO_2 was introduced into the furnace by being added to the tangential air flow at the burner. Controlling these dopant gases allowed simulation of a wide range of NO_x and SO_2 emissions.

3.3 EMISSIONS SAMPLING

The sampling stack connected to the water-cooled junction is an insulated stainless steel pipe approximately 18 cm in diameter. Ports are installed along the pipe to enable several samples of stack gas to be extracted. Just past the water-cooled junction is a particulate matter filter through which the gas sample for SO_2 analysis is drawn. A schematic of the emissions monitoring/sampling system is shown in Figure 2. Particulate matter filters inside the stack are capable of blocking particles greater than 20 µm in diameter.

In these tests, the SO_2 sample passed out of the stack through a port and into a Mott sintered metal filter that removed all particles ≥ 0.5 µm. The resulting "particulate matter-clean" gas was passed on to an ultraviolet analyzer through a heated sample line maintained at approximately 350 °C. The SO_2 sample entered the measurement cell of the analyzer, was drawn through by a pump, and passed through a rotameter at the outlet.

A gas sample for analysis of NO_x, CO_2, CO, and O_2 was drawn through a particulate matter filter at another port in the stack section. The sample passed through a Hankison drying unit, then traveled to a junction where it was split into two portions; one was analyzed for NO by the chemiluminescent method, the other for CO, CO_2, and O_2. Only NO concentration was determined because it was found during initial testing that NO_2 concentration contributes less than 5 percent to the NO_x value. The NO sample stream was drawn through a rotameter and directly into a chemiluminescent analyzer. The sample was then exhausted to a stack.

The second portion of the split sample passed through a canister of anhydrous $CaSO_4$ then was split into three streams. Each stream passed through a rotameter and into the respective analyzer (CO_2, CO, O_2). CO and CO_2 were each detected and measured in separate infrared emissions analyzers, while the O_2 level was measured by a paramagnetic oxygen analyzer. These remaining sample streams were then exhausted to the atmosphere. Outputs from all the analyzers were recorded on strip chart recorders. The previously mentioned analyzers remained on-line for the duration of all

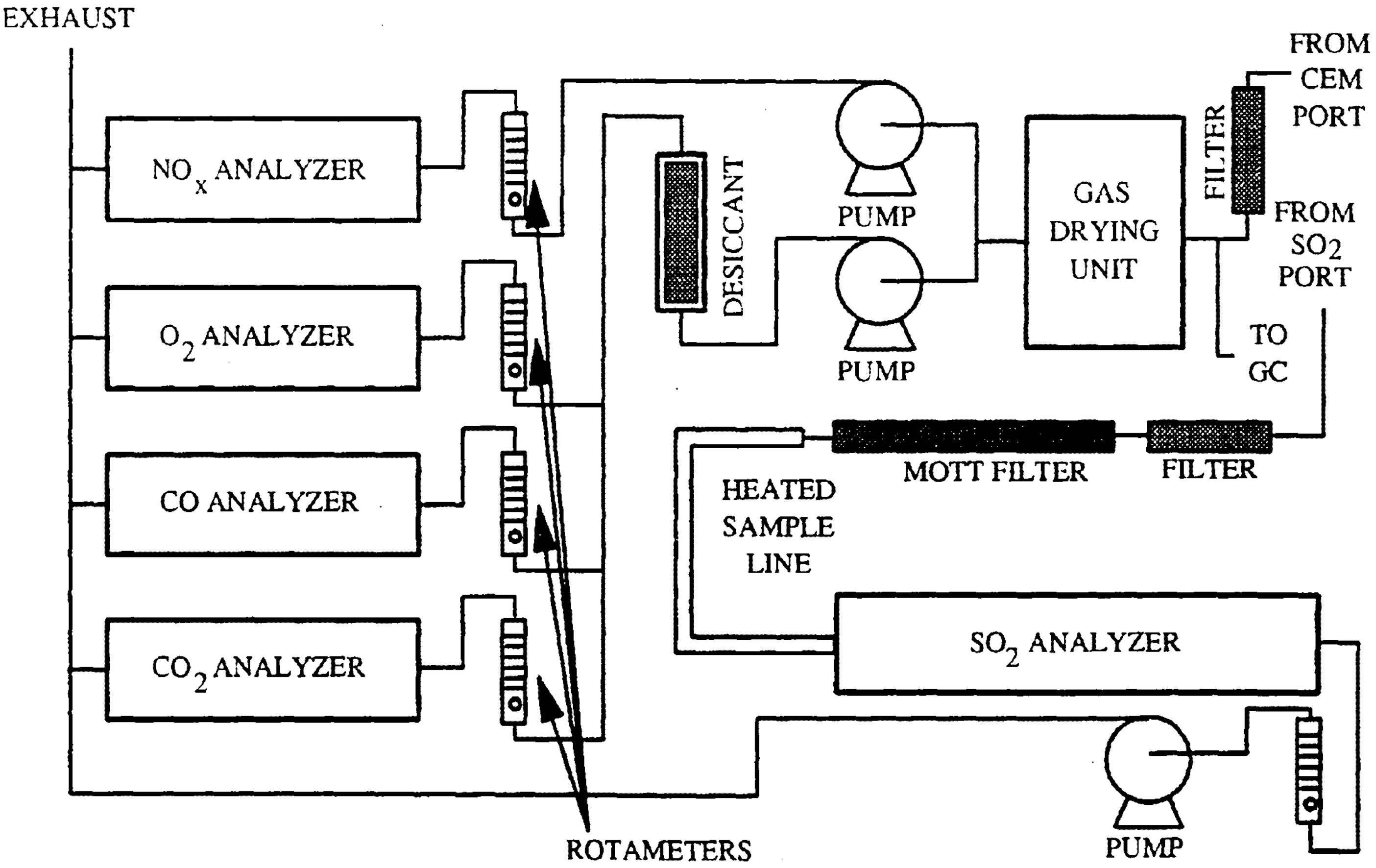


Figure 2. Flue gas components sampling system.

trials and were zeroed and spanned with gases of known concentration before and after each daily trial. The span gases used for all analyzers bracket the expected concentrations of effluent components. All measured values for NO, CO_2, CO, O_2 were corrected for the removed flue gas water based on calculation from fuel and injected water.

N_2O samples were analyzed by two different methods. Schematics of the N_2O sampling systems are shown in Figure 3. A gas chromatograph, equipped with an electron capture detector, two columns, and employing a backflush method to prevent interference from higher molecular weight compounds, was used to take grab samples of stack gas before and during sorbent/reducing agent injections.[11] A second analyzer, a tunable diode laser (TDL), monitored real-time stack N_2O emissions. The TDL is an experimental analyzer that uses laser light tuned to the same wavelength as the infrared absorption line of a known N_2O span gas. The stack gas N_2O infrared absorption line is then compared to the known laser output, and through a series of electronic components simulating second derivative spectroscopy, the stack gas concentration of N_2O is output to a strip chart recorder. This method and apparatus, detailed further in Reference 12, were calibrated for this work at 20-80 ppm, with an accuracy of ± 0.75 ppm. The two methods' results were comparable. Tests conducted at six varying conditions showed a linear correlation coefficient exceeding 0.99 between the two methods (for further comparison of N_2O analytical methods see Reference 13).

Ammonia stack gas concentrations were determined by withdrawing a stack gas sample through high flow, inline 10 μm filters and bubbling it through a solution of 0.02 -- N H_2SO_4. An equipment layout is shown in Figure 4. The gas was drawn through the impingers by a pump and the amount of stack gas sampled was monitored by a dry gas meter connected in-line. Approximately 20 L of stack gas passed through the impingers for any one test at about 2 L/min. After the sample was drawn, the impingers were washed with deionized water (DI H_2O) into a 500 mL volumetric flask. The total solution volume was then brought to 500 mL with DI H_2O. The solution was then analyzed for NH_3 with an ion selective electrode (ISE) by the following method. A 100 mL sample of the 500

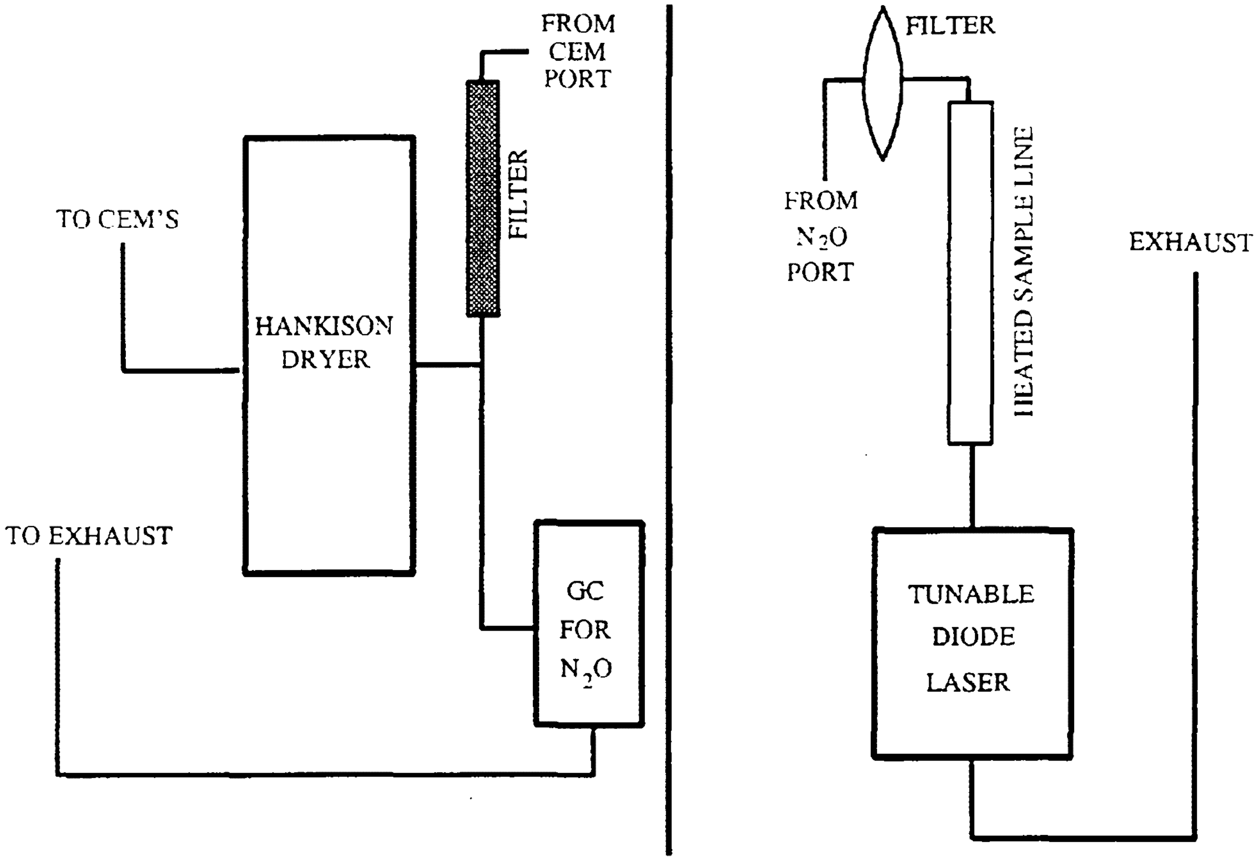


Figure 3. Schematic of the two methods of N_2O sampling.

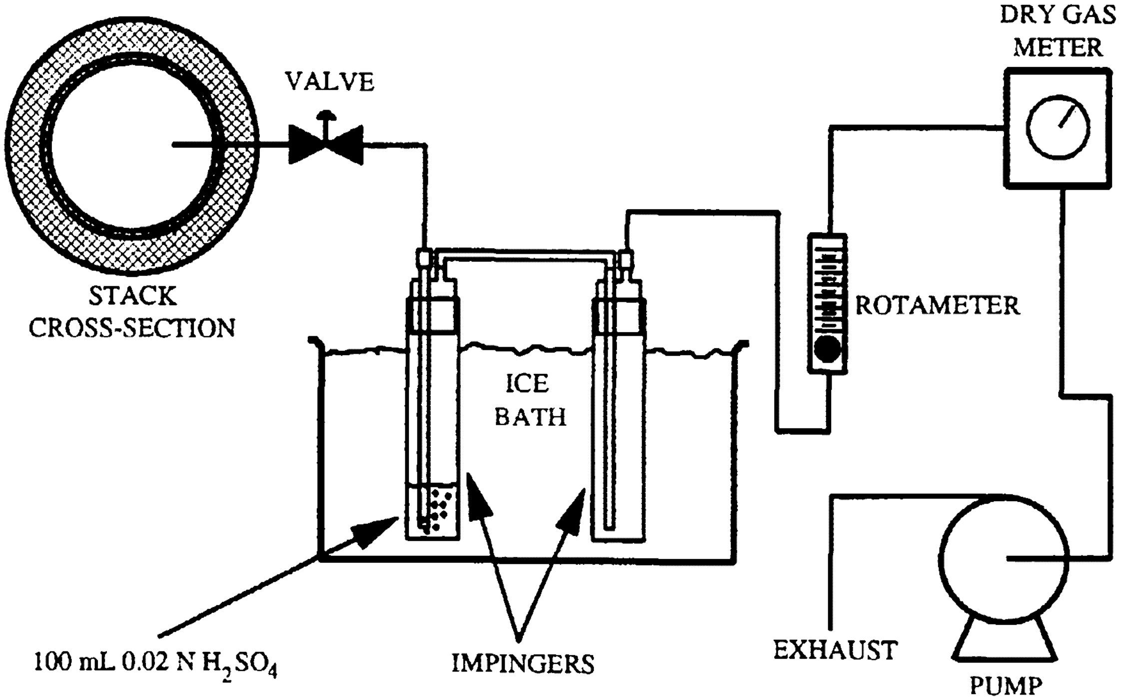


Figure 4. Ammonia sampling apparatus.

mL NH_3 solution was transferred to a 125 mL Erlenmeyer flask. As a pH adjustor, 1 mL of 10 M NaOH solution was added. A stir bar was placed in the flask, and the solution was alowed to stir for about 1 min. The ISE was then immersed into the stirred flask solution where it began to equilibrate. A meter monitored NH_3 concentration as well as how quickly the reading changed. An indicator on the meter indicated when the concentration reading stabilized and the reading was recorded.

The ISE meter was calibrated with known standards before any NH_3 determination. The resulting calibration curve was checked against the known limits of the meter. In all instances during the program, calibration of the meter fell well within limits designated by the manufacturer. All NH_3 measurements were corrected for flue gas water by accounting for water from combustion and injection.

3.4 SOLID SAMPLING

Solid samples were collected with the apparatus shown in Figure 5. A solid sampling port at the bottom of the refractory-lined section of the furnace was uncovered and a water-cooled sampling probe was inserted into the furnace center. The probe opening (about 2.5 cm) faced up toward the downward flow of reacted solids. The reacted solids were aspirated into the probe isokinetically to not bias the collected particle size. The solids were drawn out of the probe through a heated sample line and captured on filter paper in an enclosed filtering unit. The resulting cleaned gas was then passed through ice-chilled impingers that cooled the gas to condense moisture. The dry gas passed through a gas meter that was monitored to maintain the correct sampling rate. After sufficient sample had been collected, the filter paper was removed from the unit and the sample volume carefully scraped from the paper.

Solid samples collected were tested for resistivity, a measure of the ability of the solid to be collected by an electrostatic precipitator. Some of these solid samples were analyzed by X-ray diffraction to identify reaction compounds. Diffraction analyses were run on a Siemens diffractometer with a copper Kα target source running at 50 kV and 40 mA.

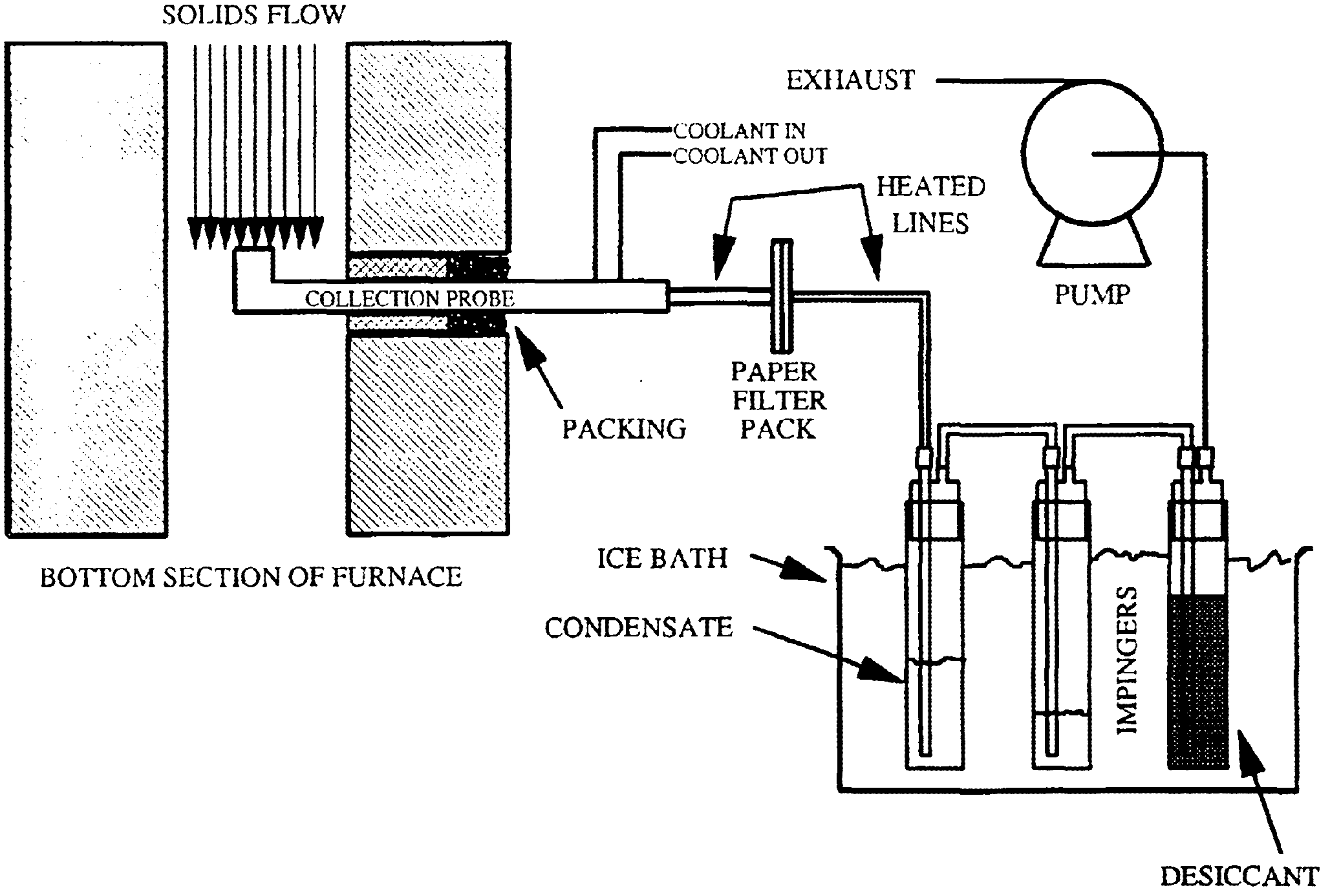


Figure 5. Solid sampling system.

3.5 SORBENT DELIVERY

Sorbent was injected into the furnace by two methods (see Figures 6 and 7). Dry sorbent (either $Ca(OH)_2$ or $CaCO_3$) was loaded into a hopper mounted on a K-Tron loss-in-weight, twin-screw, dry materials feeder. The dry sorbent feeder is a totally enclosed and pressurized system. During runs, sorbent transport air was supplied to the feeder where it traveled into a delivery line to the water-cooled injection probe. Injection air flowed continuously during trials as part of the furnace air supply. When injection took place, the feeder screws were started and the sorbent was metered into the air stream. The feeder was calibrated gravimetrically before and after each run. All sorbent feeder settings were then determined for trial use.

Slurried sorbent was prepared by adding a predetermined amount of sorbent to DI H_2O in a mixing tank. A mixing motor provided power to an impeller to keep the sorbent in constant suspension. DI H_2O was metered into a spray nozzle by a peristaltic pump where it mixed with air. The water sprayed into the furnace was used to establish baseline conditions. During sorbent injection, a valve switched the pumped liquid from water to the slurry mix. After the injection, flow was switched back to water. NO_xOUT solution was metered into the slurry stream at the probe inlet; the flow was produced by a dual syringe pump. A typical slurry injection run involved establishing a baseline condition (with water injection), injecting slurry without NO_xOUT flow, adding NO_xOUT to the slurry flow, and finally returning to baseline water injection. In instances where NO_xOUT was injected without slurry, it was metered in with the water flow at the nozzle inlet.

Dry and slurry injection required two different types of injectors. The dry injection probe was constructed of three concentric stainless steel tubes. The interior tube forming the injection orifice is 0.64-cm x 0.089-cm wall thickness tubing and is protected from furnace heat by a water jacket formed by a 0.95-cm tube placed inside a 1.27-cm tube. This jacket enclosed the 0.64-cm delivery tube. The three are welded together and a cooling water inlet/outlet is provided. The three tubes are bent

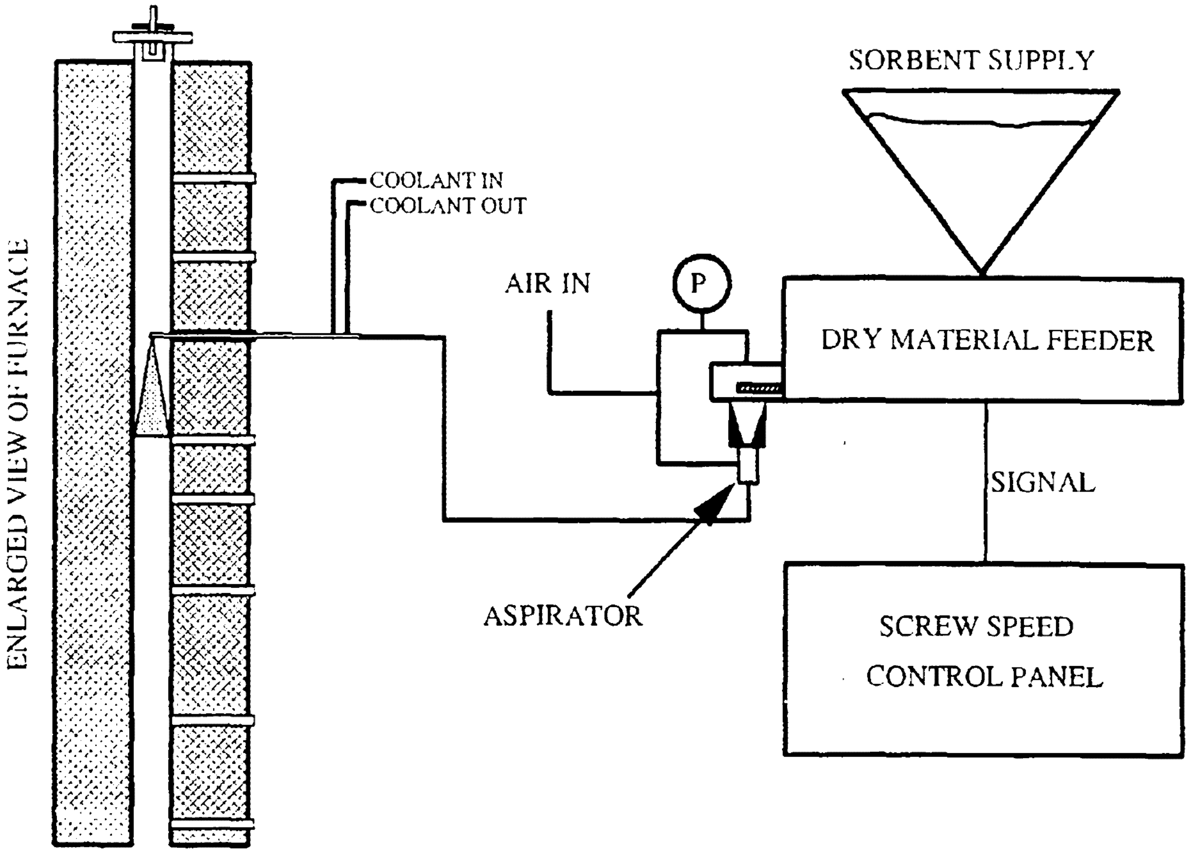


Figure 6. Equipment schematic for dry injection.

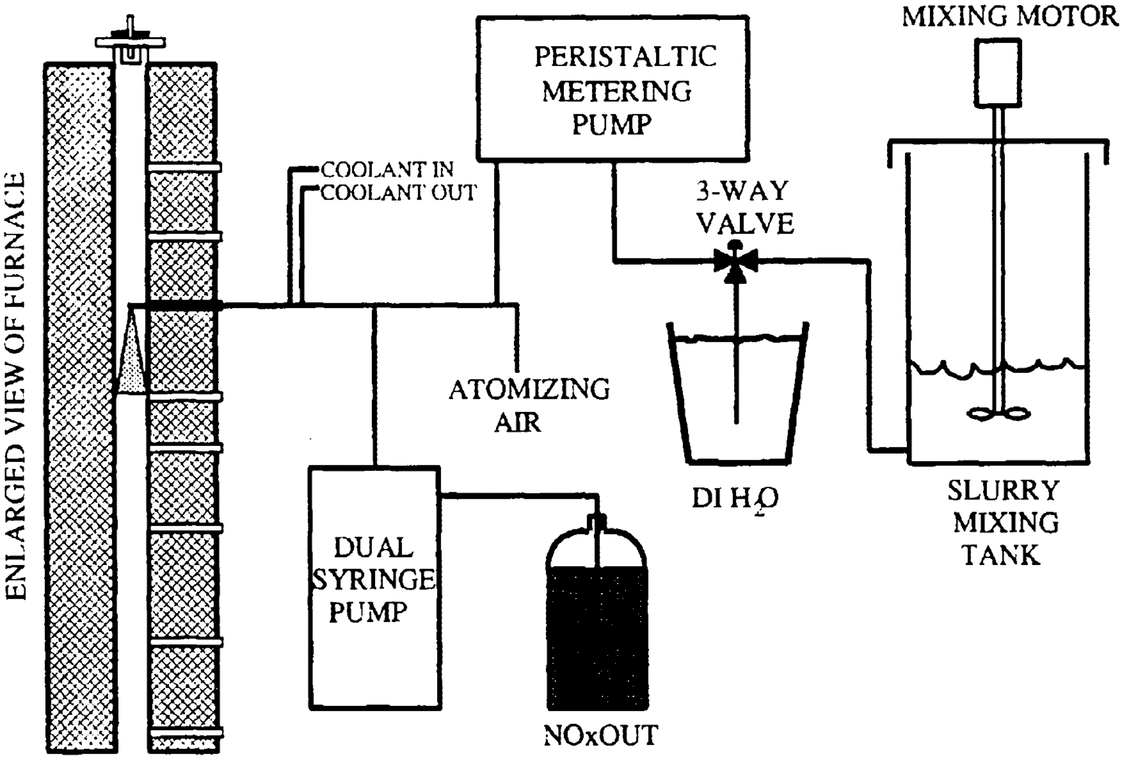


Figure 7. Equipment schematic for slurried injection.

together in a smooth radius at a 90° angle so that placing them into the injection ports on the side of the furnace allows the orifice to point downward.

Slurry was injected into the furnace through an injection probe with a 3-mm orifice. The probe was commercially manufactured by Turbotak and is constructed of stainless steel in much the same way as the dry probe and is water-cooled. Three inlets at the supply end of the probe allow water (or slurry), air, and NO_xOUT to mix before being sprayed into the furnace. The probe is about 90 cm long and 3 cm in diameter with no bends. The orifice is drilled at 90° to the axis of the interior supply tube giving a downward spray.

Actual sorbent particle size was determined by using a Micromeritics Sedigraph Model 5100. For slurry injections, a Munhall particle size classifier determined spray droplet size produced by the spray nozzle. Water and air flows through the nozzle were set to actual run conditions. The spray produced was passed through a low-intensity laser beam produced by the Munhall device. The diffraction of the laser light by the spray stream was analyzed by computer software provided with the Munhall to determine an average spray particle size. In early classification of the nozzles, a wide range of air and water flows and pressures were examined. The flows that produced the most uniform tiny spray particles were chosen for actual injections.

3.6 TEMPERATURE PROFILES

Furnace temperature profiles were determined using a suction pyrometer. All injection conditions (coal or natural gas firing) were profiled. The applicable injection conditions were set up in the furnace for testing at a particular injection port. The suction pyrometry probe was inserted two or three ports below the injection port and allowed to equilibrate. During these tests, no sorbent was used, but the applicable injection air and water were fed through the nozzle. After equilibration, the reading was recorded and the pyrometry probe moved to the next higher port. Again, after equilibration, the reading was taken. The final reading was taken at the port just below the injection point. These data points allowed a temperature profile to be drawn for dry and wet injection during coal or natural gas firing at any port. The resulting line allowed extrapolation over the distances between ports to arrive at the correct port temperature. A typical profile during natural gas burning is shown in Figure 8.

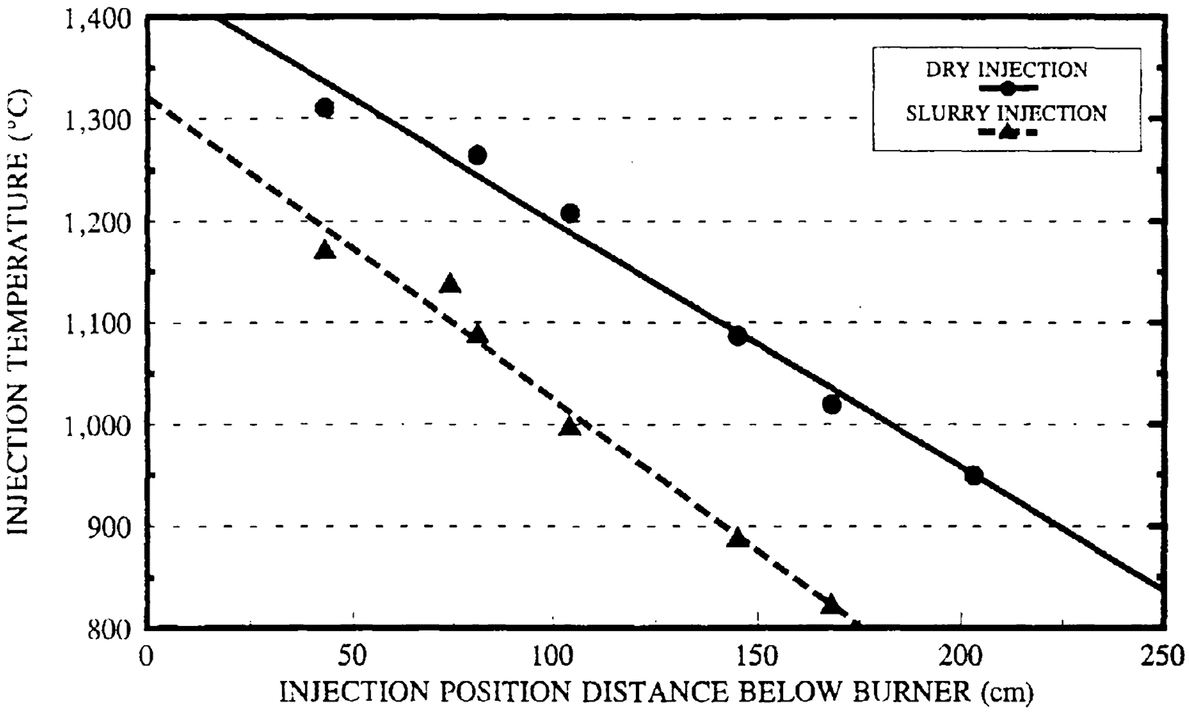
3.7 WASTE SOLID RESISTIVITY

As described in Section 3.4, collected solid samples were measured for resistivity by a procedure detailed in Reference 14. Adding calcium-based sorbent to typical coal fly ash changes the overall characteristics of the mixture, making measurement by standard methods impossible, therefore, a modified method was developed. $Ca(OH)_2$ contained in the sample decomposes at about 300 °C, accompanied by large changes in particle surface area. Older methods used for coal ash analysis were performed at temperatures in excess of 450 °C. The newer method employs temperatures less than 250 °C so as not to initiate a change in the $Ca(OH)_2$ present in the sample. In addition, older methods measure resistivity as a function of increasing sample temperature. The newer method begins at the higher temperature and records resistivity as temperature decreases. The resistivity measurements on solid samples collected during these trials were performed in a 5 percent humidity chamber.

3.8 TESTING AND CALCULATIONS

Data produced during trials were recorded on an "Innovative Furnace Data Log" form. All data collected during the trial program are included in Appendix A. Furnace set-up conditions and trial notes were written in the blanks provided at the top of the form. The data logged during the trial, including O_2, CO_2, CO, NO_x, and SO_2 concentrations, were written in the tabular matrix in the center of the page. This section also includes sorbent feed information. The bottom of the sheet also provides furnace set-up information such as air and gas flows. These data were used for material balance calculations.

The starting point for many of the calculations involved determining the total flue gas flow (Q). This value was required to calculate Ca/S ratios and was found by determining molar flows of



	DISTANCE BELOW BURNER (cm)	DRY INJECTION TEMPERATURE (°C)	SLURRY INJECTION TEMPERATURE (°C)
PORT 2R	43	1,311	1,170
PORT 3R	74	NM	1,137
PORT 3M	81	1,265	1,087
PORT 4U	104	1,209	997
PORT 4L	145	1,087	887
PORT 5	168	1,020	821
PORT 6	203	950	NM

Figure 8. Temperature profile of furnace during dry and slurry injection while firing natural gas (including tabulated temperature vs. injection location data).

NM = Not measured.

input air and natural gas from the known rotameter settings, then calculating the resultant flows of combustion products.

For natural gas burns, the combustion reaction can be considered as follows:

$$CH_4 + 2O_2 \longrightarrow 2H_2O + CO_2$$

The furnace usually runs with roughly 20-25 percent excess air so the above reaction consumes 100 percent of the natural gas. Combustion air is dried ambient air assumed to be 21 percent O_2 and balance N_2.

The molar flows (at STP) of the supplied air and natural gas were calculated from pressure and float heights from rotameters:

Let: P_x = pressure at rotameter x in bars
H_x = observed flow on calibrated rotameter in standard L/min at 25 °C (1 bar)
F_x = flow of supply air/gas in standard L/min at pressure P_x
M_x = molar flow of gas/min
Then: $F_x = H_x * (1 + P_x)^{1/2}$
$M_{air} = F_{air} * [1 \text{ mol}/24.1 \text{ L}]$
$M_{air\ total} = M_{axial\ air} + M_{tangential\ air} + M_{sorbent\ air}$
$M_{N2} = 0.79 * M_{air\ total}$
$M_{O2} = 0.21 * M_{air\ total}$

Because methane is less dense than air, a correction factor must be introduced into the equation to convert methane volumetric flow to molar flow. This correction factor is the square root of the ratio of the densities (ρ) of CH_4 and air.

$$M_{CH_4} = F_{CH_4} \times \left[(\rho_{air}/\rho_{CH_4})\right]^{1/2} \times \left[1\ mol/24.1\ L\right]$$

One mole of CH_4 consumes 2 moles of O_2 and forms 3 moles of products.

Then: $M_{O2.excess} = M_{O2} - [2 * M_{CH4}]$
$M_{CO2} = M_{CH4}$
$M_{H2O} = [2 * M_{CH4}] + M_{slurry\ water}$
$Q = M_{N2} + M_{O2.excess} + M_{H2O} + M_{CO2}$ (in moles per min)

NOTE: molar slurry water flow is determined from flow information on the daily trial data log form.

The molar ratio of injected calcium to sulfur in SO_2 is calculated as follows:

Let: D = flow of dry sorbent in grams/min
$[SO_2]$ = SO_2 concentration in furnace at baseline in ppm, wet basis
Then:

$$Ca/S = \frac{\left(D/MW_{sorbent}\right)}{\left(\left[SO_2\right] / 1{,}000{,}000\right) \times Q}$$

For coal burning conditions:

Let: F_{coal} = coal flow in grams/min
W_{sulfur} = fraction sulfur in coal (w/w)
MW_S = molecular weight of sulfur
Then: Ca/S =

$$Ca/S = \frac{\left(D/MW_{sorbent}\right)}{\left(F_{coal} \times W_{sulfur}\right)/MW_s}$$

In any instances where furnace concentrations of flue gas components are reported or used for calculations, they have been corrected to 0 percent excess O_2 to account for furnace inleakage and excess combustion air. This calculation is as follows:

Let: [X] = the actual furnace concentration of component X in ppm
$[O_2]$ = the concentration of O_2 in the furnace in percent
Then: $[X]_{0\%O2} = [X] * \{21/(21 - [O_2])\}$

Removal percentage of SO_2 or NO_x during injections is calculated:

Let: $[C]_{BL}$ = concentration of NO_x or SO_2 at baseline in ppm, wet basis
$[C]_{test}$ = concentration of NO_x or SO_2 during injection in ppm, wet basis
Then: Removal percent = $\{1 - ([C]_{test}/[C]_{BL})\} * 100$
$[C]_{BL}$ is the average of the component concentration before and after the injection, while $[C]_{test}$ is the concentration during the injection.
N/NO_{xi} was calculated from NO_xOUT flow, composition, and baseline NO_x concentration:

Let: $[NO_x]_{BL}$ = baseline NO_x concentration in ppm, wet basis
ρ = the NO_xOUT solution density
L = flow of NO_xOUT in mL/min
W_{urea} = fraction urea in solution (w/w)
MW_{urea} = molecular weight of urea

Then:

$$N/NO_{xi} = \frac{\left[\left(\left(L \times \rho \times W_{urea}\right)/MW_{urea}\right) \times (2\,molsN/mol_{urea})\right]}{\left(\left[NO_x\right]_{BL}/1{,}000{,}000\right) \times Q}$$

3.9 SLURRY INJECTION NOZZLE CHARACTERIZATION

Two slurry injection nozzles were acquired for use in the testing. One nozzle was purchased from Turbotak, Inc. (of Canada), and the other was acquired from Caldyn (of Germany). Before the nozzles were used in actual testing, a set of tests were devised to investigate the spray characteristics of each to determine the conditions that would produce the minimal spray droplet size.

Spray droplet size was determined with a particle size analyzer purchased from the Munhall Co. The analyzer (Model No. PSA-32) is of the forward diffraction, Fraunhofer-type. It measures the diffraction of laser light on a focusing lens which passes the diffracted light to a multi-ring photodiode detector. The detector then outputs the generated signals to a processor which provides a visual display of results.

Each nozzle was characterized with the air and liquid flows to be used during in-furnace operation. The spray droplet size and distribution was then measured in an out-of-furnace test. Because each nozzle was similar in design and construction, one nozzle was used to 'zero-in' on the specific optimal air and liquid flow settings. Once this step was completed, the other nozzle was set up identically and compared.

Variation of liquid flow rate was only slightly effective in reducing droplet size, while carrier air pressure (at constant mass flow) had a significant effect on droplet size. Optimal pressure was found to be about 4.8 bar at a volumetric air flow of about 1.18 standard L/s. Liquid flow rate was set at about 50 mL/min. The Turbotak, Inc. nozzle resulted in a droplet D_{50} of about 13 μm (D_{90} = 88 μm), while the Caldyn nozzle achieved a D_{50} of 10 μm (D_{90} = 60 μm). Although the Caldyn nozzle did provide superior atomization, it was not engineered with the correct cooling jacket, therefore, the Turbotak, Inc. nozzle was chosen for the trial work. Data from characterizing the Turbotak nozzle are shown in Figures 9 and 10.

3.10 SORBENT TYPE

The sorbents used in the testing were from a single source; they were commercially prepared $Ca(OH)_2$, $CaCO_3$, and CaO from the Tenn Luttrell Company. The sorbents were provided in 20-L steel buckets. All sorbent containers were kept tightly sealed when not in use to prevent any moisture or CO_2 in the room air from contaminating the supplies. Particle size analyses were performed on the received sorbents; diameters (D_{50}) determined by sedimentation were 2.55 μm, 5.80 μm, and 12.5 μm for the $Ca(OH)_2$, CaO, and $CaCO_3$, respectively.

3.11 AMMONIA SOLUTION INJECTION

To collect data for comparison with results from other researchers, NH_3 solution was injected at varying temperature and reductant/pollutant stoichiometry. This solution was prepared by diluting a given quantity of NH_4OH solution with DI H_2O. The resultant preparation was then injected into the furnace in a manner identical to the NO_xOUT injection.

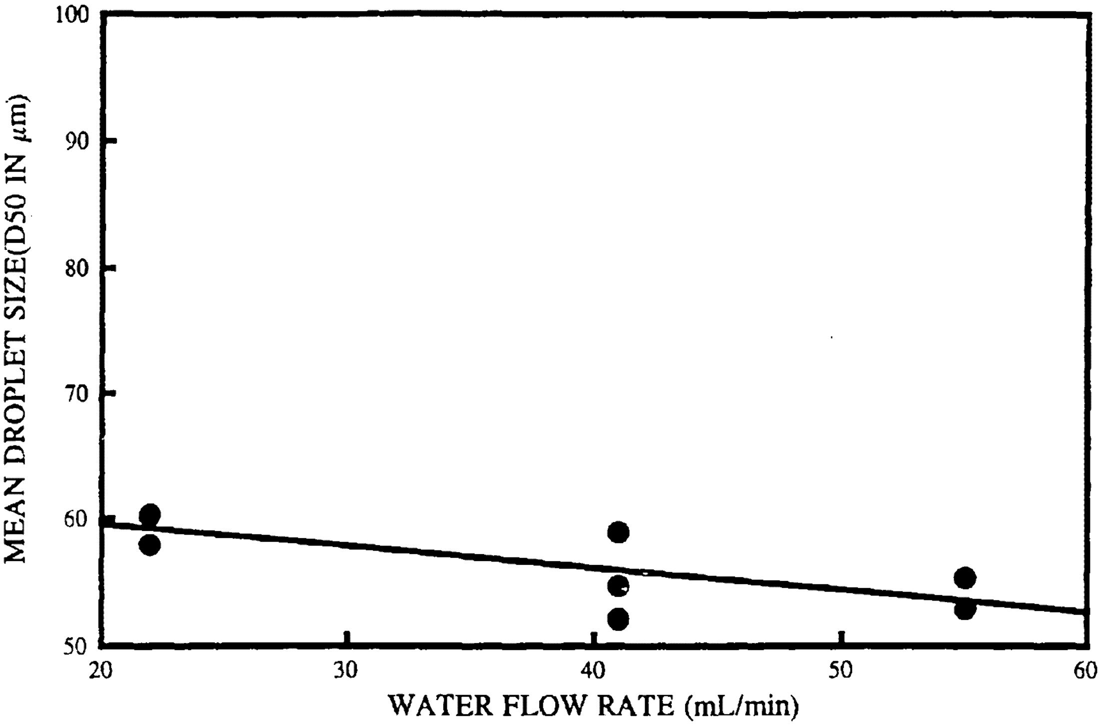


Figure 9. Spray droplet size as a function of liquid flow.

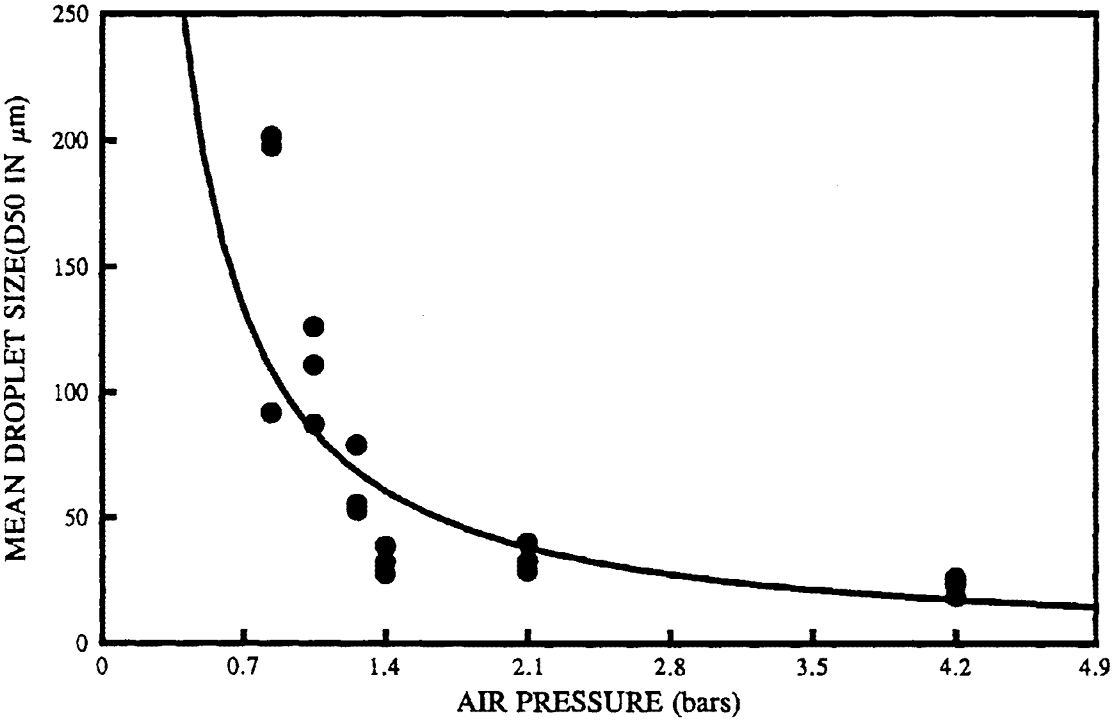


Figure 10. Spray droplet size as a function of carrier gas pressure.

SECTION 4

QUALITY ASSURANCE

4.1 QUALITY ASSURANCE PROCEDURES

Data collected during all projects conducted on the IFR are subject to scrutiny under guidelines provided by a predetermined Quality Assurance (QA) Project Plan. The plan regulates furnace operation, data collection devices, and procedures. The major parameters measured in the furnace are coal feed rate, natural gas flow rate, combustion air flows, dry sorbent feed rate, slurry sorbent feed rate, urea feed rate, slurry composition, furnace temperature profile, and flue gas composition, namely, SO_2, NO/NO_x, CO, CO_2, and O_2. The data quality objectives for each of these parameters are shown in Table 1. If during any time, the data quality objectives of any measured parameter are not met, the Project Engineer and Acurex Environmental QA Officer confer to decide on a course of remedy. Combustion conditions are verified by comparing O_2 and CO_2 levels against theoretical values obtained from certified analysis of burned coal. Natural gas combustion conditions are verified by comparing calculations of theoretical O_2 and CO_2 present in the effluent based on the natural gas feed rate and combustion air flow.

As stated in Section 3.2, continuous emission monitors are zeroed (with zero-grade N_2) and spanned before and after each daily trial with gases of known concentration. Table 2 lists the calibration information applicable to the gas analyzers. The two analyzer response values are used to calculate a percent difference value. If this value exceeds 10 percent (the precision value given in Table 1) during any time, the device is checked for proper operation, and repaired if necessary.

TABLE 1. DATA QUALITY OBJECTIVES FOR MEASURED PARAMETERS

	MEASUREMENT METHOD	COMPLETENESS (%)	ACCURACY (%)	PRECISION (%)
GAS FEED RATE	ROTAMETER	90	±10	±10
COAL FEED RATE	GRAVIMETRICALLY	90	±10	±10
COMBUSTION AIR FLOWS	ROTAMETERS	90	±10	±10
SORBENT FEED RATE	GRAVIMETRICALLY	90	±10	±10
UREA FEED RATE	SYRINGE PUMP	90	±10	±10
SLURRY FEED RATE	VOLUMETRICALLY	90	±10	±10
SLURRY COMPOSITION	GRAVIMETRICALLY	90	±10	±10
TEMPERATURES	THERMOCOUPLES	90	±10	±10
SO_2 CONCENTRATION	ULTRAVIOLET	90	±10	±10
NO/NO_x CONCENTRATION	CHEMILUMINESCENT	90	±10	±10
CO CONCENTRATION	INFRARED	90	±10	±10
CO_2 CONCENTRATION	INFRARED	90	±10	±10
O_2 CONCENTRATION	PARAMAGNETIC	90	±10	±10
PARTICULATE SAMPLING	PNEUMATIC EXTRACTIVE	90	NONE	NONE

(temperature units are °C)

TABLE 2. CALIBRATION PROCEDURES FOR PROCESS MEASUREMENT/FEED DEVICES

	PROCEDURE	MULTI-POINT CALIBRATION RANGES	REQUIRED EQUIPMENT AND REAGENTS	CALIBRATION FREQUENCY
SO_2 ANALYZER (5000 ppm RANGE)	1. ZERO WITH N_2 2. MULTI(3) POINT WITH SO_2	70-90% URL 40-60% URL 5-20% URL	CERTIFIED SO_2 CYLINDER AND GAS DILUTION CHAMBER	SEMIANNUAL MULTI-POINT CALIBRATION. DAILY HIGH SPAN AND ZERO CHECK.
NO/NO_x ANALYZER (1000 ppm RANGE)	1. ZERO WITH N_2 2. MULTI(3) POINT WITH NO	70-90% URL 40-60% URL 5-20% URL	CERTIFIED NO CYLINDER AND GAS DILUTION CHAMBER	SEMIANNUAL MULTI-POINT CALIBRATION. DAILY HIGH SPAN AND ZERO CHECK.
CO ANALYZER	1. ZERO WITH N_2 2. MULTI(3) POINT WITH CO	70-90% URL 40-60% URL 5-20% URL	CERTIFIED CO CYLINDER AND GAS DILUTION CHAMBER	SEMIANNUAL MULTI-POINT CALIBRATION. DAILY HIGH SPAN AND ZERO CHECK.
CO_2 ANALYZER	1. ZERO WITH N_2 2. MULTI(3) POINT WITH CO_2	70-90% URL 40-60% URL 5-20% URL	CERTIFIED CO_2 CYLINDER AND GAS DILUTION CHAMBER	SEMIANNUAL MULTI-POINT CALIBRATION. DAILY HIGH SPAN AND ZERO CHECK.
O_2 ANALYZER	1. ZERO WITH N_2 2. MULTI(3) POINT WITH O_2	70-90% URL 40-60% URL	CERTIFIED O_2 CYLINDER AND GAS DILUTION CHAMBER	SEMIANNUAL MULTI-POINT CALIBRATION. DAILY HIGH SPAN AND ZERO CHECK.
ROTAMETERS	PERFORM MULTIPOINT CALIBRATION WITH DRY GAS METER	80-100% FULL SCALE 50-70% FULL SCALE 10-30% FULL SCALE	DRY GAS METER, STOP WATCH, VACUUM PUMP	INITIALLY AND UPON REPAIR/REPLACEMENT
STRIP CHART RECORDER	CHECK STRIP CHART READING AGAINST INPUT VOLTAGES	80-100% FULL SCALE 50-70% FULL SCALE	CONSTANT VOLTAGE SOURCE AND DIGITAL VOLTMETER	ANNUALLY
COAL/SORBENT FEEDER	PERFORM MULTIPOINT CALIBRATIONS	NORMAL OPERATING RANGES DURING TESTING	STOP WATCH, TARED BEAKER, SCALE	CHECK BEFORE AND AFTER RUNS
SLURRY/UREA FEEDER	SPECIFIC SETTINGS ARE CALIBRATED BEFORE EACH RUN		STOPWATCH, GRADUATED CYLINDER	DAILY, DURING RUNS

URL-upper range limit

4.2 QUALITY ASSURANCE AUDIT

A QA audit was initiated on December 4, 1991. Two gas cylinders were delivered to the testing area for analysis. The component concentration in the cylinders was unknown to operation personnel. Operation personnel were asked to analyze the contents of each cylinder and report the results. These results revealed that the analyzers audited fell well within the data quality objectives established. A memorandum describing the results of this audit, from the Project QA Officer, is provided in Appendix B.

SECTION 5

RESULTS AND DISCUSSION

5.1 GENERAL

All results from sorbent injection tests were developed into percent SO_2 removal vs. Ca/S ratio graphic relationships. Data collected during the trials were entered into a spreadsheet. The equations previously expressed in Section 3.8 of this report were used. Through a series of calculations, percent SO_2 removal, corresponding Ca/S ratio, percent NO_x removal, and N/NO_{xi} were produced. A typical trial, encompassing a full work day, entailed injecting a sorbent (either dry or slurried) at constant temperature while varying Ca/S ratio. Duplicate data at each Ca/S ratio were collected. The resulting removal and stoichiometry values were then plotted. Percent removal was plotted on the y-axis, while Ca/S (or N/NO_{xi}) was plotted along the x-axis. A third-order polynomial expression was curve fit through the plotted points. Lotus Freelance (the graphics software package used) yielded the equation of the curve which allowed determining removal at Ca/S of exactly 2. All subsequent expressions of SO_2 removals in this report are at a Ca/S value of 2. Data collected throughout the trial work are presented graphically in Appendix D.

5.2 SULFUR DIOXIDE TESTS

Initial tests compared the SO_2 removal of slurry against dry injection modes for $Ca(OH)_2$ and $CaCO_3$. Figure 11 shows the effect of varying injection temperature on the SO_2 removal by $CaCO_3$ at a Ca/S ratio of 2. The SO_2 removal during dry $CaCO_3$ injection was fairly independent of injection temperature, given the relative error in the plotted values (± 5 percent based on previously run replicate tests) and showed a maximum of about 42 percent. Slurry injection appeared to have relative

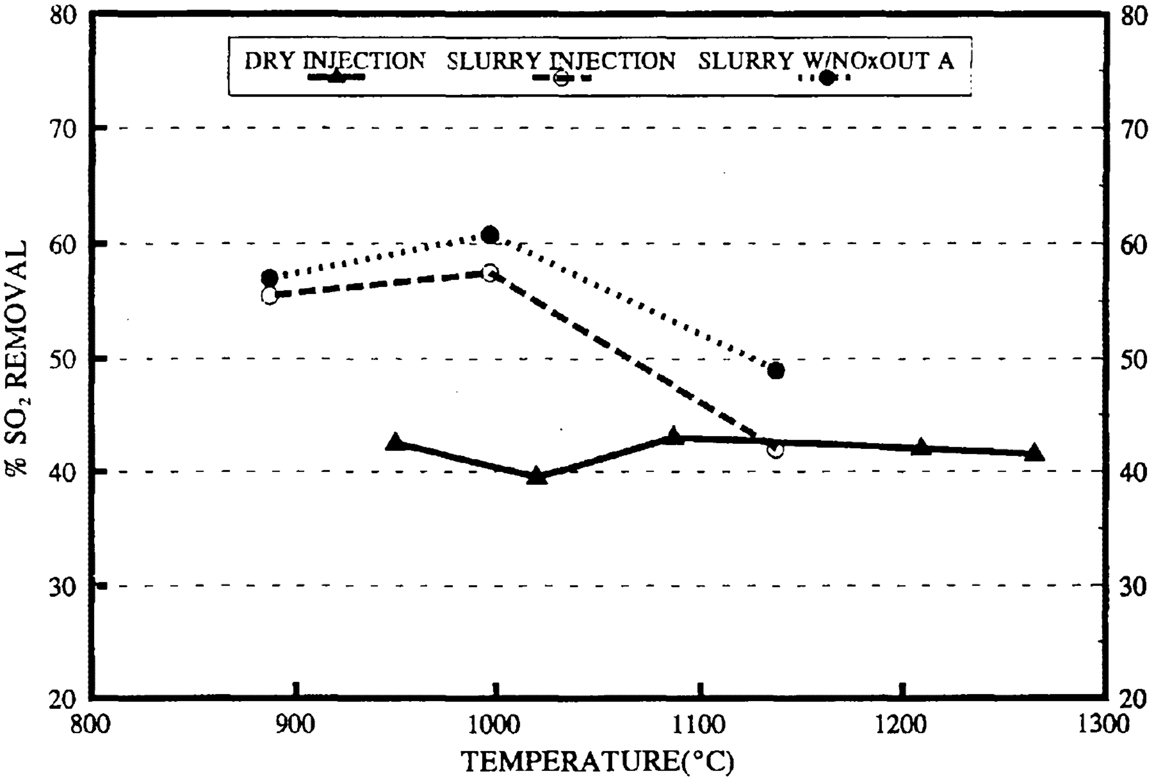


Figure 11. Effect of injection temperature on SO_2 removal in $CaCO_3$ tests ($Ca/S = 2$, $SO_{2i} = 2{,}500$ ppm).

maxima in SO_2 removal, about 57 percent around 1,000 °C. Adding NO_xOUT A solution to the slurry water (replacing an equal volume of water) may have caused a slight increase in SO_2 capture, but insufficient runs were completed for statistical certainty. The same tests for dry injection of $Ca(OH)_2$ (Figure 12) indicate that SO_2 removal, with an apparent optimum injection temperature above 1,000 °C, was relatively independent of injection temperature. The slurry injection curve is similar to the dry sorbent injection curve except for a significant increase in SO_2 removal by slurry injection around 1,000 °C, where SO_2 capture increases to about 72 percent. Tests with urea (NO_xOUT A) added to the slurry water followed the temperature response of the sorbent-alone slurry, but indicated significantly higher SO_2 removal (about 10 percent, absolute), up to a maximum around 82 percent capture.

Limited tests were also done with commercially available Tenn Luttrell CaO (lime). In these tests, $Ca(OH)_2$ was tested against a CaO slaked with the slurry injection water before injection. The results (also shown on Figure 11 for a single injection temperature) indicate that injecting a CaO slaked under non-optimized hydration conditions yields equal SO_2 capture to the $Ca(OH)_2$. Similarly, injecting the slaked CaO slurry with NO_xOUT A solution resulted in equivalent capture to the $Ca(OH)_2$ with NO_xOUT A, about 82 percent at Ca/S = 2.

5.2.1 Comparison

The SO_2 removals reported in Figure 11 for dry $CaCO_3$ particles are equivalent to previous results (about 40 percent) for testing in this furnace and others[15,16]. The SO_2 removal results for dry $Ca(OH)_2$ sorbent injection, about 60 percent, are also similar to earlier testing in this reactor and numerous tests by others[15,17,18]. While comparing results between dissimilar furnaces, fuels, initial SO_2 concentrations (SO_{2i}), and sorbents is difficult, the results for $CaCO_3$ slurry injection (about 42 percent at Ca/S = 2) are consistent with results from Reference 19 of 40-55 percent at Ca/S = 2 and four different coal/sorbent combinations. Later work indicates SO_2 removals with a $Ca(OH)_2$ slurry (Ca/S = 2) of 78 percent, comparable to our peak value of ≈ 72 percent[10].

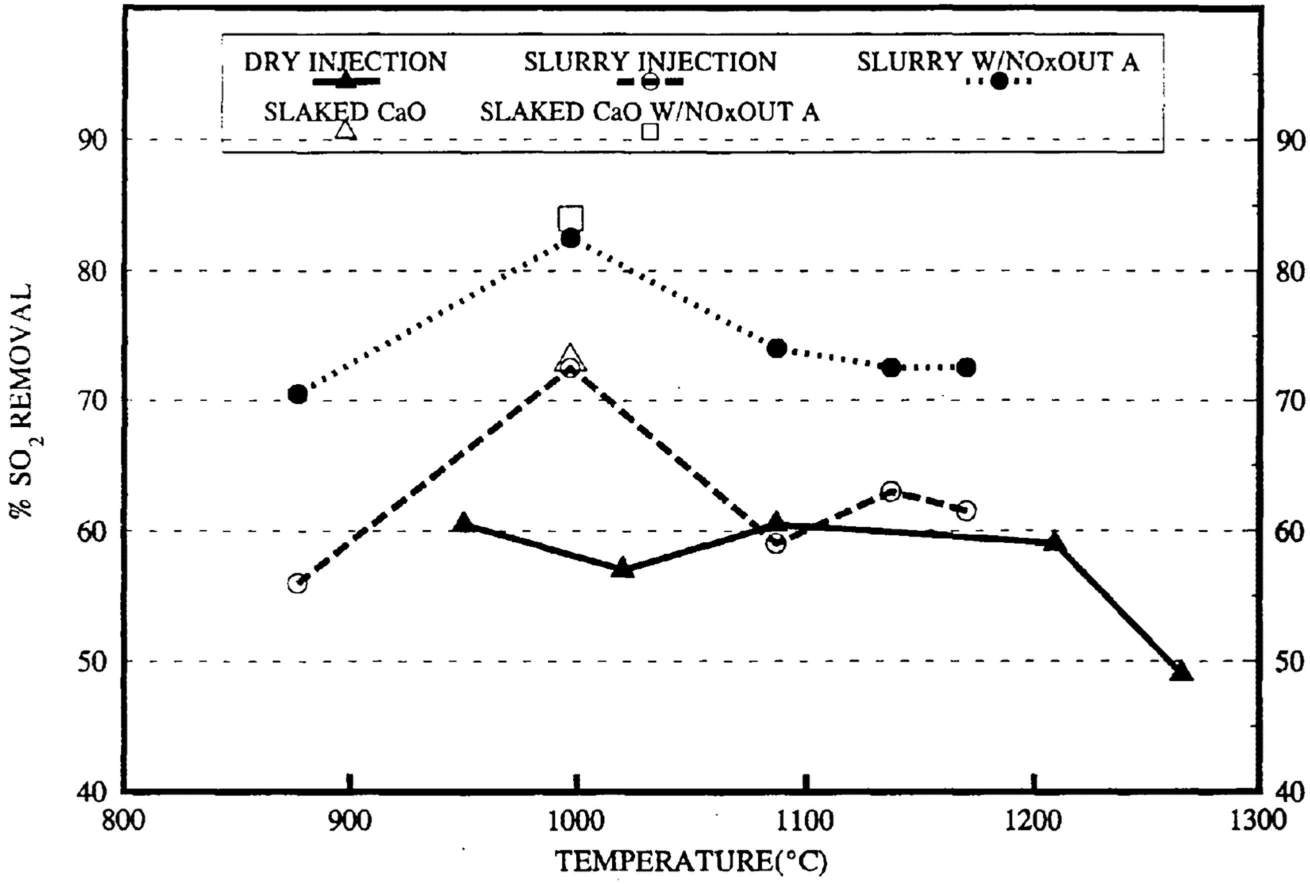


Figure 12. Effect of injection temperature on SO_2 removal in $Ca(OH)_2$ and CaO tests ($Ca/S = 2$, $SO_{2i} = 2{,}500$ ppm).

5.2.2 Temperature

The results for both dry and slurry $Ca(OH)_2$ injection (Figure 12) are similar to those found for dry and slurry $CaCO_3$ injection in that, with some exceptions, they are relatively insensitive to temperature. While greater sensitivity to injection temperature for dry sorbent injection may be observed in other facilities, this phenomenon is a strong function of reactor quench rate.[16,18] The temperature response profile of SO_2 capture becomes flatter for lower quench rates. The IFR has a fairly moderate quench rate of about 250 °C/s. Results from a pilot facility operating at a quench rate of 500 °C/s did show greater temperature sensitivity of SO_2 capture with slurry injection[16]. As expected with this higher quench rate, the optimum slurry injection temperature (about 1,200 °C) was determined to be about 200 °C higher than in our work (about 1,000 °C).

5.2.3 Dry Versus Slurry Injection

The equal or greater capture by $CaCO_3$ slurry versus dry injection has been attributed to particle fragmentation or delayed sintering[20].

The levels of SO_2 removal, approximately 60 percent (excluding the urea addition results), are typical for dry $Ca(OH)_2$ sorbents, while the range of data on our tests is insufficient to be conclusive. Significantly greater SO_2 removals (about 10 percent, absolute) with slurry versus dry injection result at one temperature (1,000 °C). Unfortunately, further definition of this temperature peak was impossible because of injection port limitations. The mechanism for this enhanced removal during slurry (vs. dry) injection remains speculative.

5.2.4 Effect of NO_xOUT A

Tests with NO_xOUT A added to the $Ca(OH)_2$ slurry showed significant improvement over the slurry alone or dry tests. Improvements in SO_2 capture of about 10 percent absolute occur at 880-1,170 °C. This phenomenon was also observed when testing a hydrated lime/urea mixture and comparing it with the hydrated lime alone[3]. The researchers speculated that the enhancement was either caused by increases in sorbent surface area and porosity from urea decomposition in the sorbent crystal structure or by reactions between SO_2 and urea decomposition products in the sampling system. Work by others has shown that SO_2 capture is possible with NH_3 alone[21]. It is possible that the NH_3 slip created by urea decomposition may be directly removing SO_2 as well. Our results suggest that the mechanism for enhancing the sorbent's ability to capture SO_2 is probably the reaction of the sorbent and urea-based compound with SO_2. X-ray diffraction results from IFR solid sampling during NO_xOUT A injection indicate, along with the expected $CaSO_4$, the significant presence of $(NH_4)_2Ca(SO_4)_2 \cdot H_2O$ (koktaite). Clearly, at these high temperatures, CaO, SO_2, and the urea breakdown product (NH_3) may react together to increase SO_2 removals beyond that expected simply from the presence of CaO [from $Ca(OH)_2$ or $CaCO_3$] alone.

5.2.5 Ca(OH)$_2$ vs. Slaked CaO

The inability to distinguish between the SO_2 reactivity of the slurries from commercially available $Ca(OH)_2$ vs. laboratory-slaked CaO suggests the simplicity of the hydration process towards producing reactive sorbents. Purchase costs of hydration and transportation of the added weight of H_2O in $Ca(OH)_2$ to the site can be avoided if CaO is mixed at the boiler site. While improved methods of CaO slaking are likely to increase the sorbent reactivity, our rudimentary methods of sorbent slaking were sufficient to match the results of manufacturer-supplied $Ca(OH)_2$.

5.2.6 Particle Size Effects

Tests varying the particle size of $CaCO_3$ sorbent were conducted for dry, slurry, and slurry with NO_xOUT A injection conditions. Results at the optimum injection temperature for SO_2 removal at a Ca/S ratio of 2/1 are compared against the $Ca(OH)_2$ results (Figure 13). Smaller particles generally remove more SO_2, whether they are $CaCO_3$ or $Ca(OH)_2$. The enhancement of dry sorbent SO_2 capture by either slurry injection or NO_xOUT A addition is probably maintained independent of particle size. Equivalently sized $CaCO_3$ was indistinguishable in removal efficiency to $Ca(OH)_2$. For slurry injection, however, $Ca(OH)_2$ is clearly superior in removal efficiency.

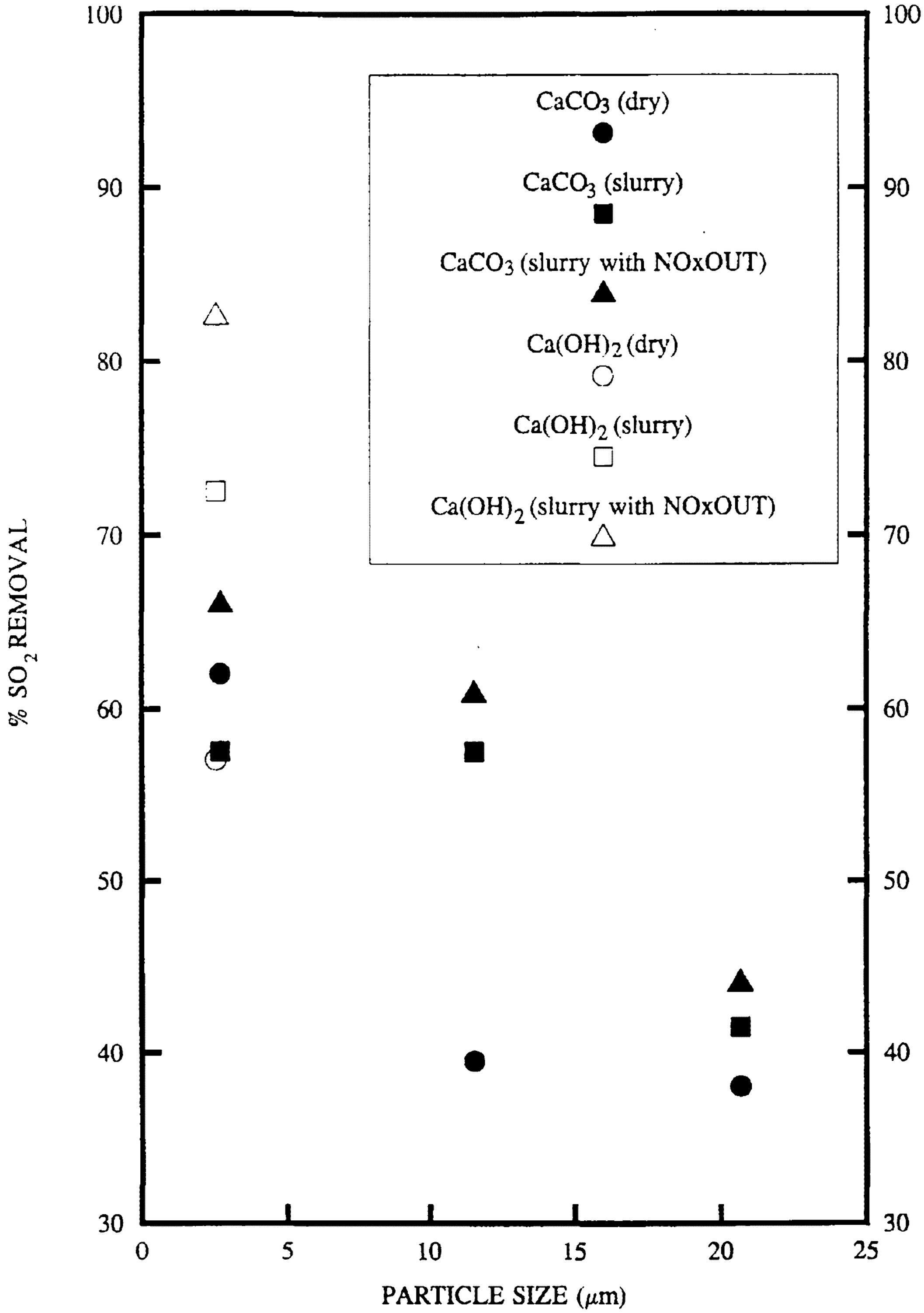


Figure 13. Effect of sorbent particle size on SO_2 removal.

5.3 NITROGEN OXIDE TESTS

Tests were conducted over a range of temperatures to measure the temperature sensitivity of both NO_xOUT A and NO_xOUT A+ reducing agents. Tests varied from about 821 to 1,170 °C with a N/NO_{xi} of about 1.5 (note that urea breaks down into 2 moles of reducing agent nitrogen per mole of urea). The results of testing with NO_xOUT A, encompassing NO_x, NH_3, N_2O, and CO emissions, are shown in Figure 14.

For reference, SO_2 removal results from slurry injection are superimposed on this figure, although these results were not obtained simultaneously. (Other results showed that the effect of concurrent sorbent injection upon NO_x removal is unnoticeable; tests with and without sorbent in the slurry did not prove to affect NO_x removals.) For NO_xOUT A, a peak NO_x reduction of 82 percent was achieved at the optimum temperature of about 1,100 °C, while NO_x reductions greater than 60 percent were obtained at injection temperatures of 950 to 1,140 °C.

In comparison to these results, Figure 15 shows the results of NO_xOUT A+. The maximum NO_x reduction was 80 percent at the optimum injection temperature of around 1,100 °C and an N/NO_{xi} of about 1.5. NO_x removals of greater than 60 percent were achieved at injection temperatures ranging from 887 to 1,137 °C.

The effect of N/NO_{xi} upon NO_x removal for NO_xOUT A and NO_xOUT A+ is shown in Figures 16 and 17, respectively. NO_x removal increases with N/NO_{xi} until around an N/NO_{xi} of 2.0, where the NO_x removal starts to level off. Figures 16 and 17 show inflections in the curves at around an $N/NO_{xi} = 1.5$, caused by including data from Figures 14 and 15. The data used to produce Figures 14 and 15 were collected during a different trial run day than those for Figures 16 and 17. Furnace temperatures vary slightly from day to day causing slight differences in the removal results.

5.3.1 N_2O

N_2O emission levels (Figure 14) for NO_xOUT A generally appear to follow NO_x removal levels; peak N_2O emission (200 ppm) occurs at a slightly higher temperature (1,137°C) than peak NO_x

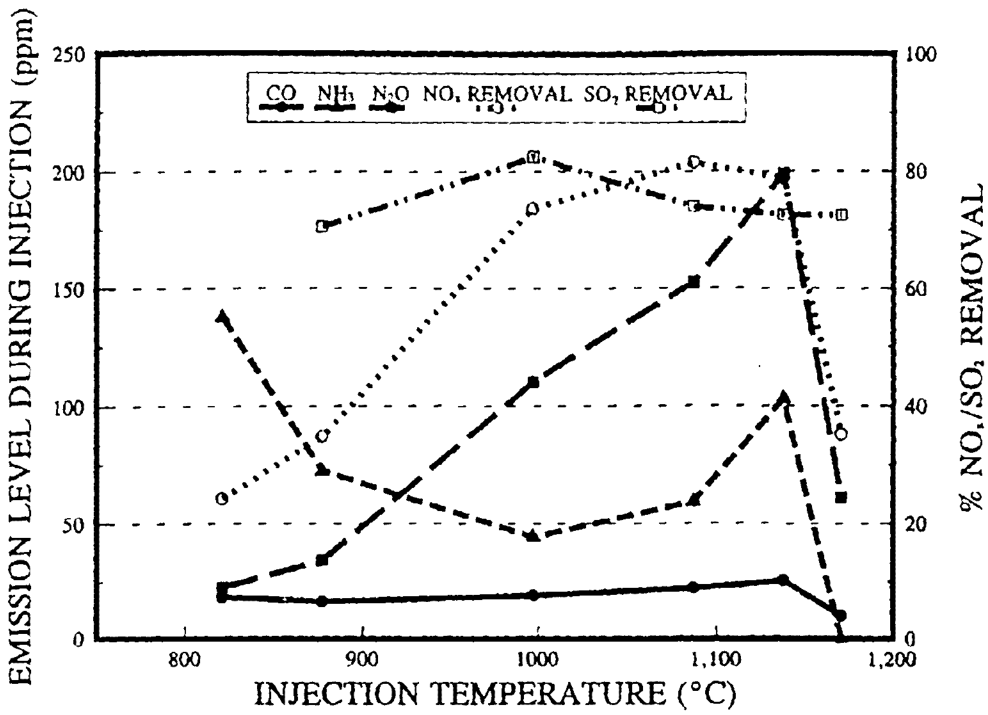


Figure 14. Effect of injection temperature on emissions using NO_xOUT A (N/NO_{xi} = 1.5. NO_{xi} = 600 ppm).

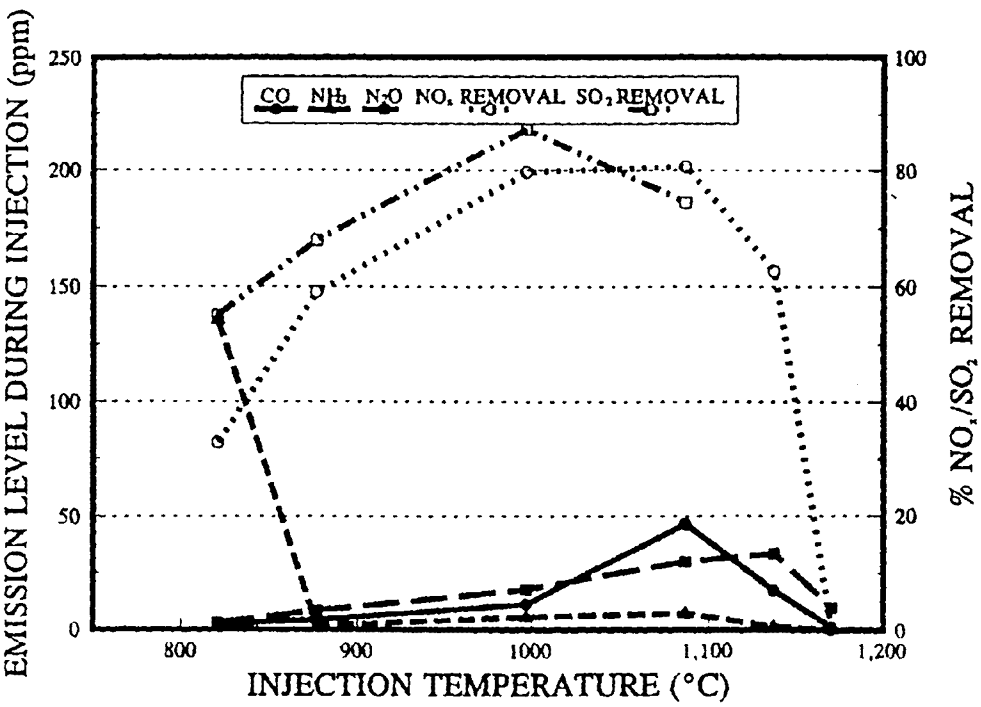


Figure 15. Effect of injection temperature on emissions using NO_xOUT A+ (N/NO_{xi} = 1.5. NO_{xi} = 600 ppm).

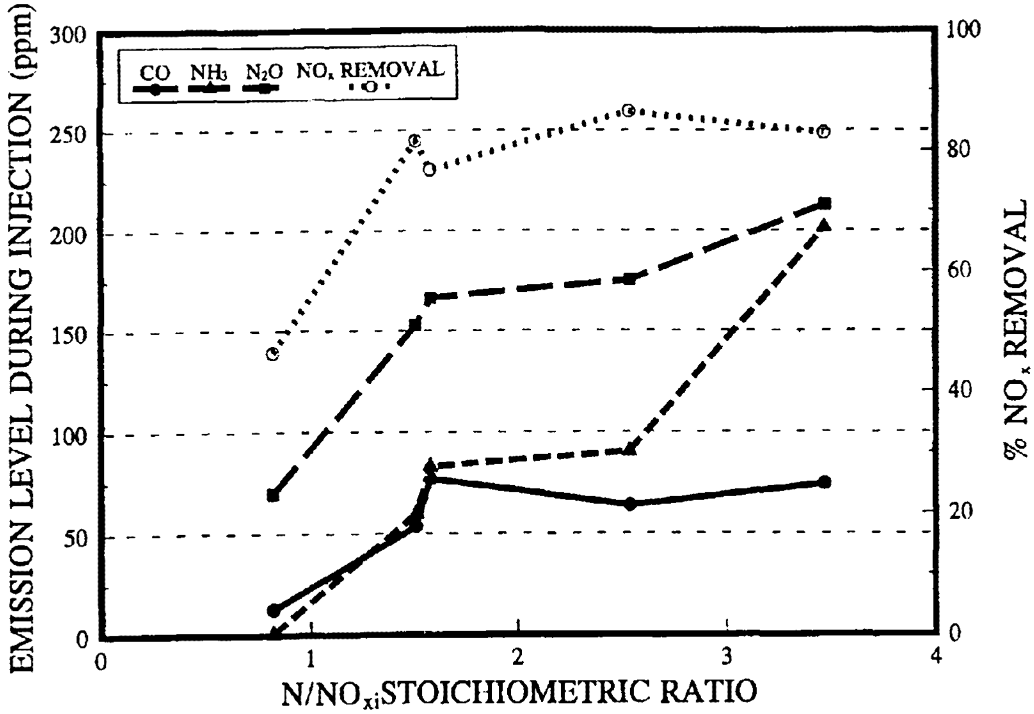


Figure 16. Effect of N/NO_{xi} on emissions using NO_xOUT A (injection temperature = 1,087 °C. NO_{xi} = 600 ppm).

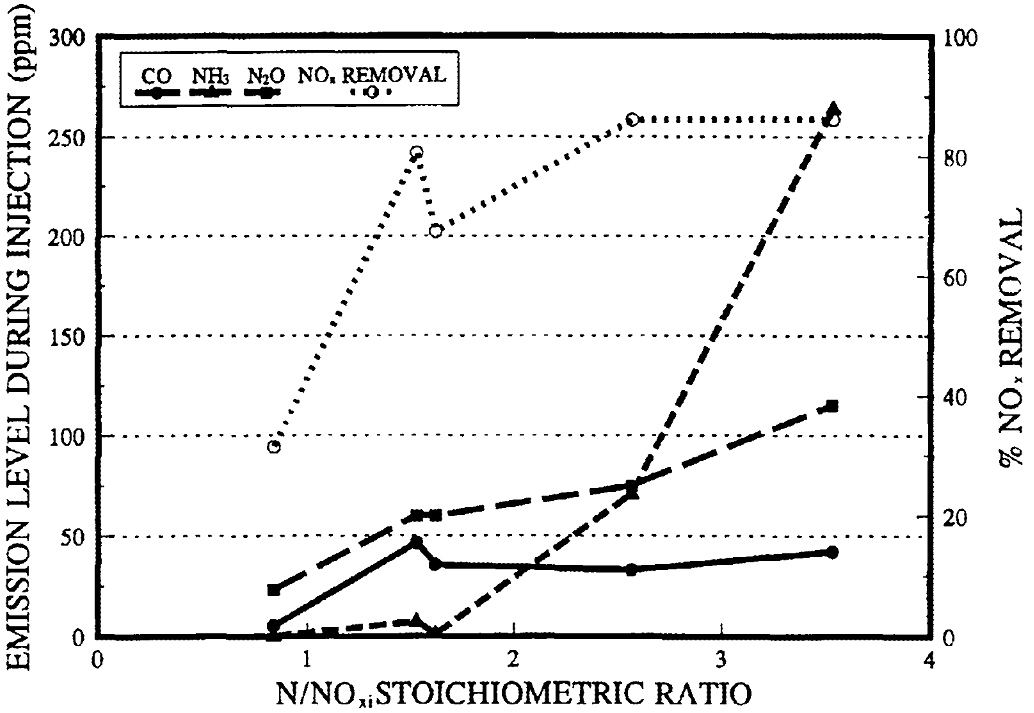


Figure 17. Effect of N/NO_{xi} on emissions using NO_xOUT A+ (injection temperature = 1,087 °C. NO_{xi} = 600 ppm).

removal (1,100 °C). Peak N_2O emissions using NO_xOUT A+ (Figure 15) appear to occur about 50 °C higher than the optimum injection temperature for NO_x removal. For both urea solutions, N_2O emissions follow a similar temperature response, although levels for the latter (peak value of 36 ppm) are consistently about one-fourth of the former.

For tests conducted near the optimum injection temperature for NO_x removal (1,087 °C), increasing N/NO_{xi} values results in greater N_2O emissions for both urea solutions (Figures 16 and 17, respectively). N_2O concentration ranges from 70-220 ppm for an N/NO_{xi} of 0.8-3.5, respectively, for NO_xOUT A. NO_xOUT A+ appears to be less sensitive to N/NO_{xi} increases, ranging from 25 to 115 ppm for N/NO_{xi} values of 0.8-3.5. For both urea-based chemicals, N_2O emissions are only slightly affected by changing N/NO_{xi} values between 1.5 and 3.5.

Injection of NO_xOUT A at near optimum temperature (1,087 °C) with $Ca(OH)_2$ slurry at varying Ca/S ratio resulted in N_2O production of 66 ppm, 51 ppm, and 64 ppm at Ca/S about 3, 2, and 1, respectively. N/NO_{xi} was held constant at about 1.5 for this testing. Correspondingly, injection of NO_xOUT A+ yielded N_2O emissions of 35 ppm, 27 ppm, and 33 ppm at Ca/S about 3, 2, and 1. These results (not shown in a figure), when compared with Figures 16 and 17, suggest that the presence of sorbent addition may aid reduction in N_2O levels. This possibility has not been verified.

5.3.2 NH_3

NH_3 concentrations for NO_xOUT A injection (Figure 14) reach a maximum of 140 ppm at 821 °C. Increases in injection temperature show declining concentrations of NH_3 slip. Peak NH_3 levels of 135 ppm for NO_xOUT A+ (Figure 15) at 821 °C are reduced below 5 ppm at injection temperatures of 887 °C and higher.

Changes in N/NO_{xi} values affect NH_3 emissions, as seen in Figures 16 and 17. Increases in N/NO_{xi} for both urea-based solutions result in higher levels of NH_3. Unlike N_2O, NH_3 levels with NO_xOUT A and A+ are a stronger function of N/NO_{xi} changes from 1.5 to 3.5.

Coupling the reducing agent injection (at N/NO_{xi} about 1.5) with $Ca(OH)_2$ slurry near optimum injection temperature (1,087 °C) produces NH_3 slip of less than 35 ppm at Ca/S between 0.8 and 2.0 for NO_xOUT A (results not shown). Slip was somewhat less for NO_xOUT A+. A maximum of 12 ppm was observed at Ca/S between 0.8 and 2.0. The reduction in NH_3 slip during sorbent/urea co-injection could be attributed to NH_3 combining with Ca and SO_2 to form $(NH_4)_2Ca(SO_4)_2{\bullet}H_2O$ as previously mentioned.

5.3.3 Comparison

IFR test results (Figure 16) show NO_x removals with NO_xOUT A at 1,087 °C and varying N/NO_{xi} that are similar to those demonstrated in Reference 10. While less similar results have been reported by References 8 and 9 with urea injection, direct comparison is made tenuous by experimental differences in reducing agent phase (solid urea) and NO_{xi} value (250 ppm), respectively.

Tests with NH_3 solution injection were conducted to obtain data to compare others' results to assess any reactor-specific trends and validate the findings of this work, particularly in reference to N_2O and NH_3 emissions.

The NO_x removal results of NH_3 solution injection at N/NO_{xi} of 1.3 are shown in Figure 18, indicating that NO_x removal exceeds 50 percent over a fairly broad temperature range, 887-1,140 °C. These findings are fairly consistent with NO_x removal results of Reference 8 at an N/NO_{xi} of 2, given the differences in operating conditions. The NO_x removal response to varying the N/NO_{xi} of the NH_3 solution is shown in Figure 19, compared with References 4 and 8.

The NH_3 slip and N_2O emissions during injection of NH_3 water at N/NO_{xi} of 1.3 is shown in Figure 20. The decline of NH_3 slip at 827 °C is unexpected, yet was confirmed by repeated testing. Figure 21 shows the effect of N/NO_{xi} on NH_3 slip and N_2O emissions.

CO emissions reported in Figures 14-17 are included to show the effect of injection temperature and N/NO_{xi}. These emission levels, generally 40 ppm or less, are similar to those of

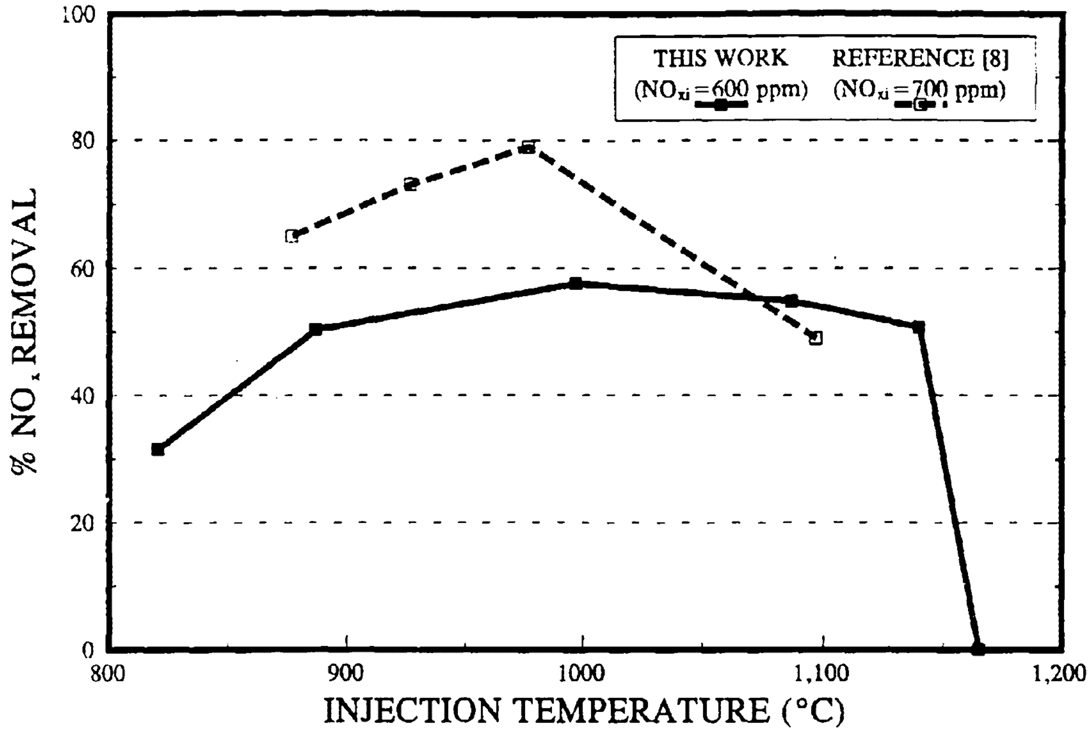


Figure 18. Effect of injection temperature on NO_x removal using NH_3 solution (N/NO_{xi} = 1.3) compared with Reference 8 (N/NO_{xi} = 2).

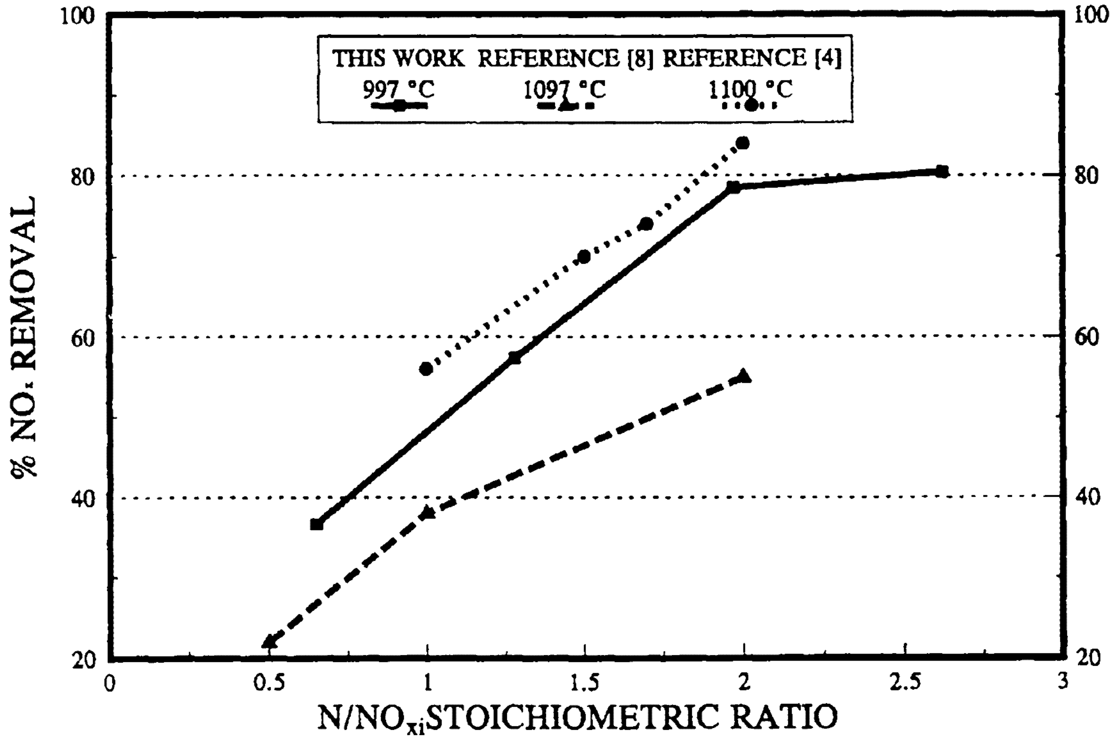


Figure 19. Effect of NO/NO_{xi} on NO_x removal using NH_3 solution (NO_{xi} = 600 ppm) compared with Reference 8 (NO_{xi} = 700 ppm) and Reference 4 (NO_{xi} = 619 ppm).

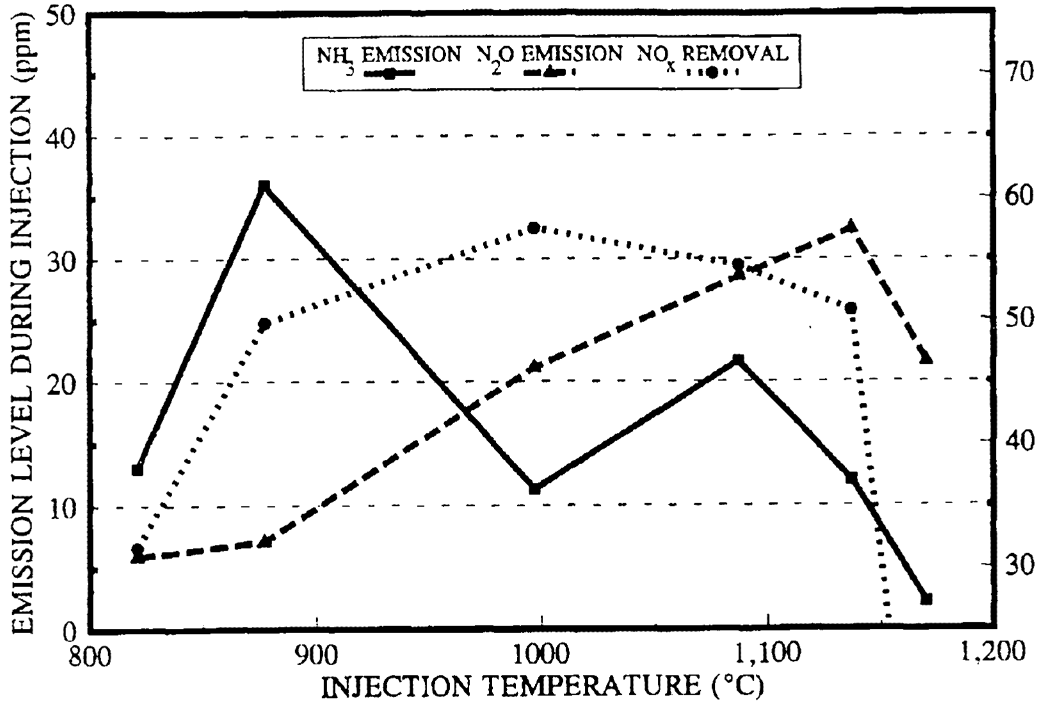


Figure 20. Effect of injection temperature on emissions using NH_3 water (N/NO_{xi} = 1.3, NO_{xi} = 600 ppm).

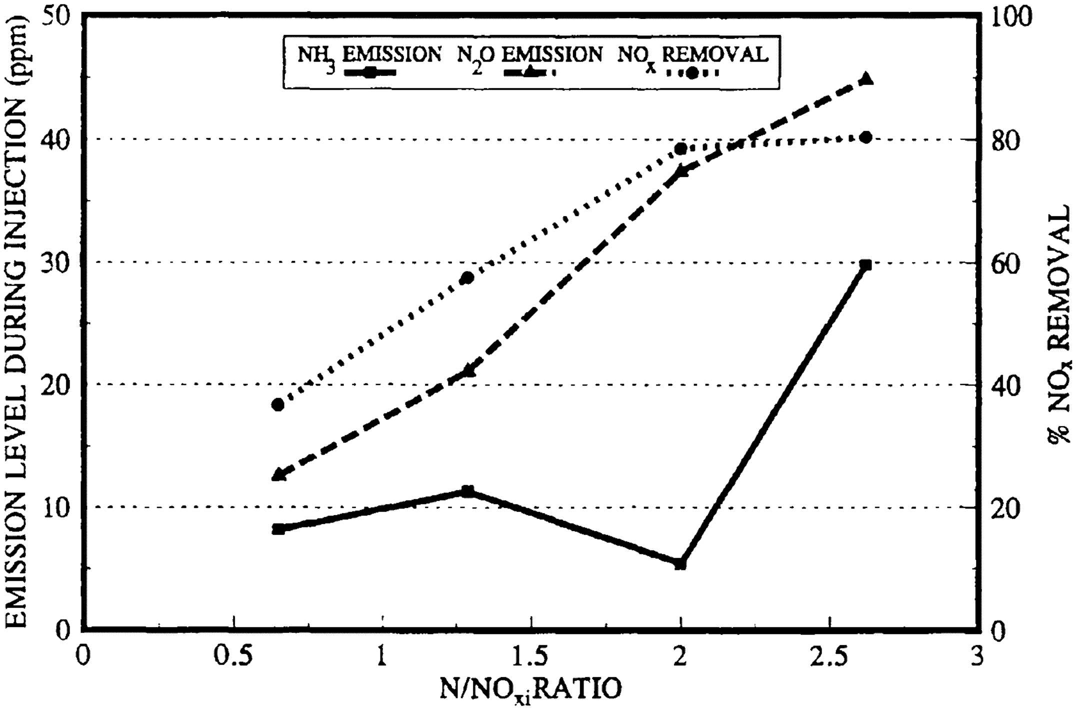


Figure 21. Effect of N/NO_{xi} on emissions using NH_3 water (injection temperature 997 °C, NO_{xi} = 600 ppm).

Reference 9. A significant increase in CO emissions at lower injection temperatures is not observed. perhaps because our injection range did not extend sufficiently low[9].

The trends seen in the NH_3 solution injection results indicate that reactor-specific differences in removing NO_x under similar testing conditions between these three laboratories are not substantial and that results obtained in our research may apply equally well to others' reactors.

Values of N_2O production as a function of NO_x reduction (plotted as $\Delta N_2O/\Delta NO_x$ in Figure 22) for NO_xOUT A+ were almost exclusively less than those of References 8 and 22 with pure urea. Work reported in Reference 8 was done on a pilot-scale, natural gas-fired combustor (described in Reference 9), doped with NH_3 to produce NO_x, and Reference 22 used a pilot-scale 2 MW (t) coal-fired circulating fluidized bed. This suggests that technical improvements to the pure urea solution, represented NO_xOUT A+ formulations, can affect N_2O emissions in SNCR processes.

Levels of NH_3 emissions for both urea-based solutions show trends of reduction with increases in temperature, consistent with results of others[9]. Figure 23 compares the NH_3 slip emissions during injection of both urea solutions with those from Reference 9. NH_3 slip values in our work are significantly less throughout the full temperature range. This may be caused by subtle differences in the experimental combustors combined with the increased reactivity of the enhanced urea formulation at lower temperatures. Use of NO_xOUT A+ vs. NO_xOUT A solution in this work improved the NO_x removal values at lower temperatures. This result raises the possibility of staged injection of these chemicals at low and high temperatures, respectively. This result also has the additional benefit of reducing the local "load" of the nitrogen-reducing agent injected into the flue gases, and thereby possibly minimizing potential NH_3 slip problems.

5.4 COAL TESTS

Very limited testing was completed under actual coal-burning conditions. Pittsburgh #8 coal (2.6 weight percent sulfur) was burned in the IFR, and the resulting combustion products treated with $Ca(OH)_2$ slurry, NO_xOUT A and NO_xOUT A+. Injections were made at 1,151 °C and 1,041 °C.

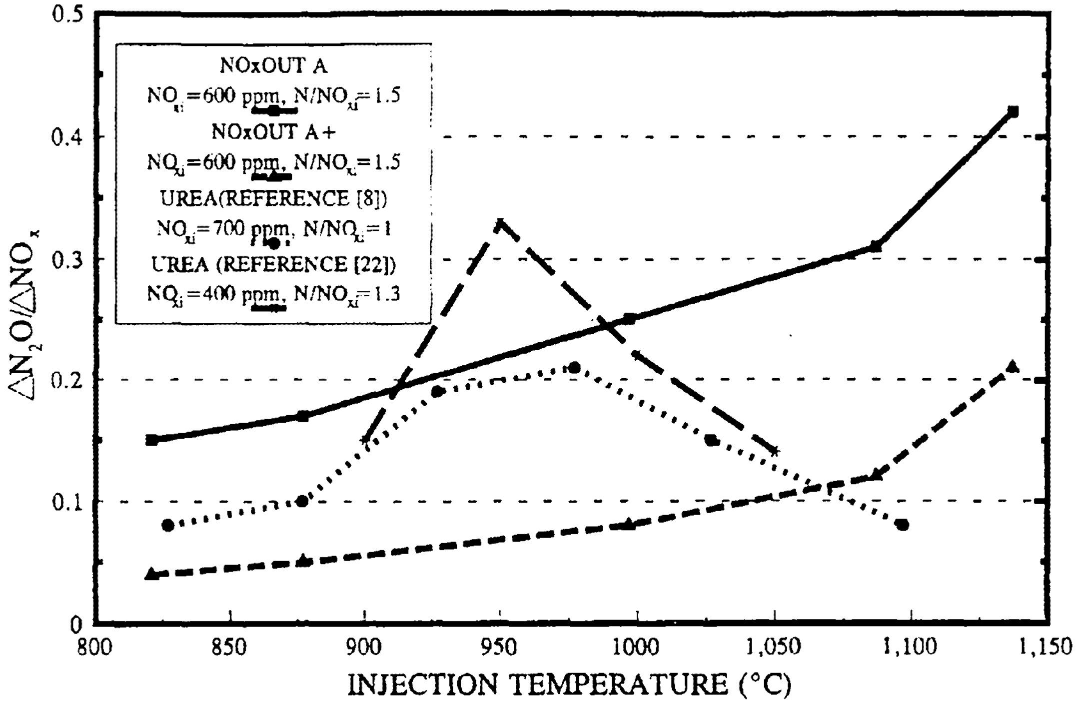


Figure 22. Effect of injection temperature on $\Delta N_2O/\Delta NO_x$.

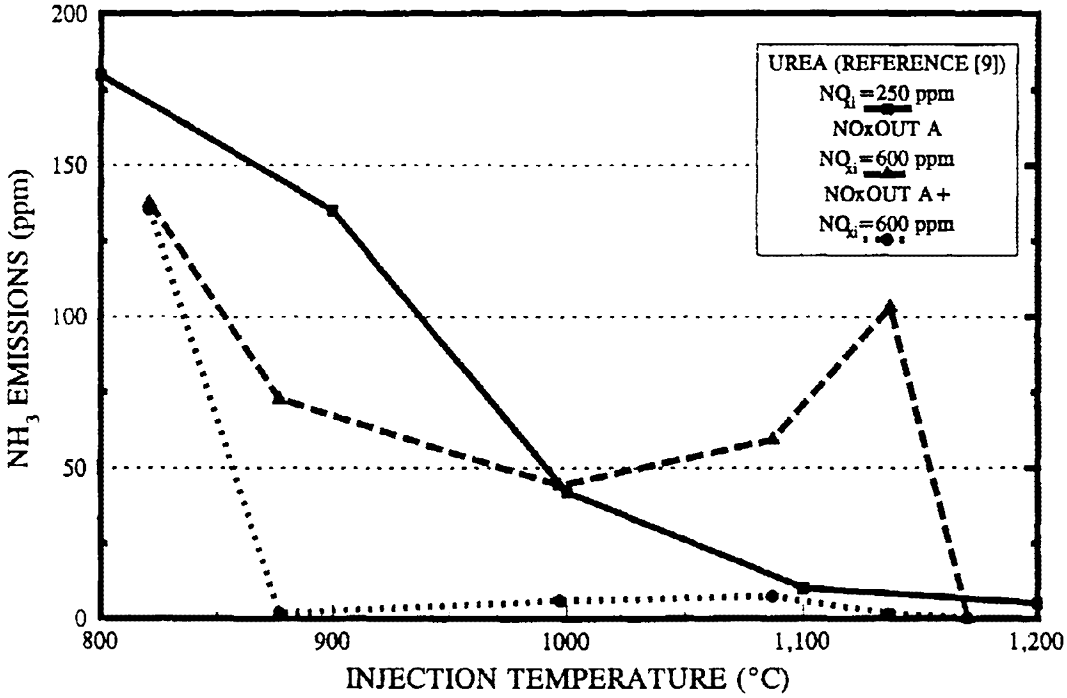


Figure 23. Effect of injection temperature on NH_3 emissions at N/NO_{xi} = 1.5 compared with Reference 9.

Injection of the slurry and NO_xOUT A at 1,151 °C gave 69 percent SO_2 removal, and 36 percent NO_x removal at stoichiometries of 4.5 and 2.6, respectively. At the lower injection temperature, the NO_xOUT A slurry improved to 86 percent SO_2 capture at Ca/S = 3.3. NO_x removal declined, however, to 19 percent at $N/NO_{xi} = 2.4$.

The NO_xOUT A+ slurry achieved 70 percent and 60 percent SO_2 and NO_x removal, respectively, at Ca/S = 4.5 and $N/NO_{xi} = 1.6$ at 1,151 °C. Injection at 1,041 °C resulted in SO_2 removal identical to the NO_xOUT A slurry at this temperature. NO_x removal was 21 percent at a lower N/NO_{xi} of 1.5.

NH_3 slip was about 19 and 10 ppm for NO_xOUT A and NO_xOUT A+, respectively, at the higher injection temperature (1,151 °C). Slip sharply increased to well above 110 ppm for both reducing agents at 1,041 °C.

N_2O production by each reducing agent was greater at 1,151 °C; NO_xOUT A generated 65 ppm N_2O while NO_xOUT A+ yielded 58 ppm. At 1,041 °C, NO_xOUT A and NO_xOUT A+ generated 43 and 18 ppm N_2O, respectively.

CO emissions during this limited testing were very high (300 ppm). The change in CO emissions during urea injection was indistinguishable because of these unusually high baseline levels. These high levels of CO are not generally experienced during coal burns on this reactor. It is believed that the burn conditions set up produced a nonrepresentative combustion effluent. This effluent could have adversely affected the obtained results; the results are certainly not consistent with those obtained during natural gas testing. Additional testing with coal could provide more information on this anomaly.

5.5 RESISTIVITY RESULTS

Four solid samples were collected for resistivity measurement. These samples were collected during injection when burning Pittsburgh #8 coal. Samples during dry injection of $Ca(OH)_2$, slurry injection of $Ca(OH)_2$, slurry/NO_xOUT A injection, and coal alone were obtained. Resistivity for the coal alone sample could not be measured by the method employed.[14] Facilities were not available to determine resistivity of coal-only fly ash by common methods. The resistivity for the sample collected during dry sorbent injection was about 7.5 X 10^{13} ohm-cm. During slurry injection the resistivity increased to about 9.1 X 10^{13} ohm-cm. A further increase to 2.0 X 10^{14} ohm-cm was realized during slurry/NO_xOUT A injection. The resultant curves generated during resistivity determinations are given in Appendix C.

Electrostatic precipitator (ESP) performance can be profoundly affected by changes in fly ash resistivity. Preferential ESP operating conditions require coal fly ash resistivity to be no more than about 10^{10} ohm-cm. Adding reacted sorbent material to the fly ash mixture causes changes in the chemical properties of the ash; the resulting resistivity is usually somewhat greater than 10^{10} ohm-cm. The results obtained from this work indicate that adding sorbent and urea to the coal fly ash causes significant increase in ash resistivity. These increases substantially exceed a level giving acceptable ESP performance.[23] High values of ash resistivity are known to cause a decrease in the current density of the particulate matter charging field which results in the degradation of ESP performance. This reduction in current density will cause sparking, or the formation of a stable back-corona.

Laboratory measurements of resistivity typically range as much as 2-3 orders of magnitude higher than field values obtained for the same material. Furthermore, the modifications made to the measurement method, because of the presence of calcium sorbents also probably resulted in higher values for resistivity. Whether or not sorbent/reducing agent injection will adversely impact particle collection has not been effectively evaluated. Flue gas conditioning methods such as the addition of humidity or sulfur trioxide may also be used to lower ash resistivity.

SECTION 6

CONCLUSIONS AND RECOMMENDATIONS

This work has demonstrated successful pilot-scale coupling of calcium-based sorbent injection with SNCR technologies in a slurry injection process. SO_2 and NO_x removals of about 60-80 percent at Ca/S = 2 and an $N/NO_{xi} = 1.5$, respectively, have been consistently observed.

SO_2 emission control is enhanced by combining the technologies. Identification of $NH_4/Ca/SO_4$ compounds suggests that the urea-based solutions react with Ca and SO_2 to effect additional SO_2 removal. Some evidence exists for the enhancement of SO_2 capture during slurry vs. dry injection of sorbents, albeit over a narrow temperature range.

NO_x removals of 60-80 percent at $N/NO_{xi} = 1.5$ were typically observed. NO_x removals greater than 60 percent were observed over a broad temperature range: 950-1,150 °C for NO_xOUT A, and 850-1,150 °C for NO_xOUT A+.

Comparative levels of NH_3 and N_2O are significantly reduced below levels previously reported for urea injection by using modified urea-based solutions. Near the peak NO_x removal levels (80 percent) for NO_xOUT A+ solution ($NO_{x,init} = 600$ ppm, $N/NO_{xi} = 1.5$), emission levels of NH_3 and N_2O were below 18 and 30 ppm, respectively.

The synergistic effect urea has shown on sorbent SO_2 capture ability has not been fully explained. This work identified the presence of $(NH_4)_2Ca(SO_4)_2 \cdot H_2O$ in reacted solids. However, the formation mechanism of this compound is unknown, as is its effect upon properties of the ash/sorbent waste.

Adding lime and urea causes chemical changes to the fly ash/sorbent mixture producing ash resistivities in excess 10^{13} ohm-cm. While resistivity values exceeding 10^{10} have been known to cause degradation in ESP performance, derivation of accurate values from laboratory-scale equipment at ambient temperature (especially in the presence of calcium sorbents) is considerably suspect.

No effort was made to further characterize urea/slurry injection in coal-fired systems; only limited information was obtained in this effort. The results were not comparable to those obtained during natural gas firing.

The process may also be broadened in its applicability to a wider market by considering options for dealing with additional pollutants (e.g., HCl and mercury) and improving emission removal performance. The latter suggestion may be accomplished by process alternatives such as staged reducing agent injection, sorbent enhancement, or a combination of technologies (e.g., SCR, sorbent recycle, multiple sorbent injections).

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APPENDIX A

INNOVATIVE FURNACE DATA LOG SHEETS

Innovative Furnace Data Log

Date: 12/3/90
Initials PWG + CBC
Test: # N1

NH_3 Rotameter [illegible]
Setting (BB height): 30
Fuel: ~~[illegible]~~ CH_3
Slurry: water
% Excess Air (measured):
Injection Port: 2nd Rt

SO_2 Rotameter
Setting (BB height):
Draft (inches of Water): 0.3
Starting Temperature: 2077 °F
(thermocouple across from injection point)
Ending Temperature: 1953°F

	Stage Air (float height)	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	NO_x OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
		7.475						
BL	1.03 @ 70	~~7.575~~	7.6	14	399 cbc	- - - -	47.2	
NSR-1	1.03 @ 70	7.625	~~7.625~~ 7.4	15	400 cbc	1.32	47.2	
BL	1.03 @ 70	7.65	7.4	15	399	—	47.2	
NSA1	1.03 @ 70	7.55	7.46	22	370	1.32	47.2	
BL	1.03 @ 70	7.65	7.44	15	400	—	47.2	
NSR1	1.03 @ 70	7.5	7.4	12	347	1.32	47.2	
BL	1.03 @ 70	7.625	7.44	18	398	—	47.2	47.35 cbc
				cbc				
BL	1.03 @ 70	7.625	15	7.38	400	—	46.5 cbc	
NSR2	1.03 @ 70	7.5	7.5	17	293	2.70	46.5	
BL	1.03 @ 70	7.7	7.4	16	400	—	46.5	
NSR2	1.03 @ 70	7.5	7.5	18	288	2.70	46.5	
BL	1.03 @ 70	7.7	7.4	15	400	—	46.5	46.2
BL	1.03 @ 70	7.775	7.3	15	398	—	45.7	
NSR3	"	7.5	7.5	30	211	4.02	45.7	
BL	"	7.975	7.24	25	394	—	45.7	
NSR3	"	7.7	7.4	28	168	4.02	45.7	
BL	"	7.95	7.26	23	390	—	45.7	45.7

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air
Start	4.551 @ 45 PSI	1 @ 45 PSI	.82 @ 2	N/A
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	N/A

Innovative Furnace Data Log

Date: 12/14/90
Initials PWG + EBC
Test: #12

NH$_3$ Rotameter Setting (BB height): 38.5
Fuel: Natural Gas
Slurry: Water
% Excess Air (measured): 53.5

SO$_2$ Rotameter Setting (BB height): 0
Draft (inches of water): 0.2
Injection Port: 3rd Right

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/mi
BL	1.03 @ 70	7.875	7.35	14	380	0	0	47.2	
NSR1	1.03 @ 70	7.06	7.8	14	225	0	1.34 ebc	47.2	
BL	1.03 @ 70	7.19	7.8	10	340	0	0	47.2	
NSR1	1.03 @ 70	7.19	7.86	14	215	0	1.34	47.2	
BL	1.03 @ 70	7.25	7.8	10	331	0	—	47.2	47.9
	@								
BL	1.03 @ 70	7.375	7.6	10	338	0	—	46.4	
NSR2	1.03 @ 70	7.05	7.9	18	108	0	2.68	46.4	
BL	1.03 @ 70	7.3	7.7	9	337	0	—	46.4	
NSR2*	1.03 @ 70	7.06	7.9	17.5	75	0	2.68	46.4	
BL	1.03 @ 70	7.25	7.5	13	335	0	—	46.4	46.2
	@								
BL**	1.03 @ 70	7.45	7.7	14	338	0	~~4.02~~ 0 ebc	45.6	
NSR3	1.03 @ 70	7.0	7.9	20	45	0	4.02	45.6	
BL	1.03 @ 70	7.325	7.74	7	340	0	0	45.6	
NSR3	1.03 @ 70	7.0	7.9	20	40	0	4.02	45.6	
BL	1.03 @ 70	7.325	7.66	7	342	0	—	45.6	45.8
	~~1.03~~ @ ~~70~~								

Furnace
Temperature at [illegible] (°F

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2082	2137	188
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2074	2071	179

*Noticed NH$_3$ BB Setting = 36.5

Innovative Furnace Data Log

Date: 12/5/90
Initials PBC
Test: N3

NH3 Rotameter
Setting (BB height): 103.5
Fuel: natural gas
Slurry: H_2O
% Excess Air (measured):

SO_2 Rotameter
Setting (BB height): N/A
Draft (inches of water): 0.3
Injection Port: 3rd middle

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	7.675	7.4	7	383	0	—	47.1	
NSR1	1.03 @ 70	7.625	7.46	10	200	0	1.34	47.1	
BL	1.03 @ 70	7.725	7.4	6	381	0	—	47.1	
NSR1	1.03 @ 70	7.625	10 ↔	7.5	185	0	1.34	47.1	
B1	1.03 @ 70	7.725	5	↔ 7.49 OK	375		—	47.1	49.0
	@								
BL	1.03 @ 70	7.875	5 ↔	7.4	375	0	—	46.3	
NSR2	1.03 @ 70	7.625	7.52	20	80	0	2.66	46.3	
BL	1.03 @ 70	7.8	7.4	12	378	0	—	46.3	
NSR2	1.03 @ 70	7.55	7.52	20	73	0	2.66	46.3	
BL	1.03 @ 70	7.8	7.36	2	379	0	—	46.3	45.7
[illegible]	@					~~0~~			
BL	1.03 @ 70	7.825	7.36	3	375	0	—	45.7	
NSR3	1.03 @ 70	7.475	7.54	15	38	0	4.02	45.7	
BL	1.03 @ 70	7.95	7.4	4	373	0	—	45.7	
NSR3	1.03 @ 70	7.5	7.6	21	28	0	4.02	45.7	
* BL	1.03 @ 70	7.75	7.42	5	360	0	—	45.7	45.9
	@								

Temperature at ~~Port~~ Furnace Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2138	2199	1952
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2110	2111	1842

* NO Level Dropped Due To NH3 Drop from 103.5 BB To 100.5 BBS

Innovative Furnace Data Log

Date: 12 / 5 / 90
Initials ebe TPWG
Test: #N4

NH$_3$ Rotameter Setting (BB height): ~~110~~ ebe 111
Fuel: natural Gas
Slurry: H$_2$O
% Excess Air (measured): 50%

SO$_2$ Rotameter Setting (BB height): N/A
Draft (inches of water): 0.3
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	8.125	7.06	6	360	0	—	27.2	
NSR1	1.03 @ 70	8.00	7.16	13	198	0	1.34	27.2	
BL	1.03 @ 70	8.075	7.14	6	363	0	—	27.2	
NSR1	1.03 @ 70	8.0	7.1	14	200	0	1.34	27.2	
BL	1.03 @ 70	8.1	7.06	5	361	0	—	27.2	27.2
	@								
BL	1.03 @ 70	7.8	7.3	6	375	0	—	46.5	
NSR2	1.03 @ 70	7.65	7.4	25	53	0	2.68	46.5	
BL	1.03 @ 70	7.825	7.26	6	375	0	—	46.5	
NSR2	1.03 @ 70	7.675	7.44	27	52	0	2.68	46.5	
BL	1.03 @ 70	7.8	7.24	7	374	0	—	46.5	46.0
	@								
BL	1.03 @ 70	8.0	7.2	7	375	0	—	45.2	
NSR3	1.03 @ 70	7.58	7.4	32.5	35	0	4.02	45.2	
BL	1.03 @ 70	7.9	7.25	10	375	0	—	45.2	
NSR3	1.03 @ 70	~~8.11~~ 7.56	7.4	35	29	0	4.02	45.2	
BL	1.03 @70	7.87	7.25	10	383	0	—	45.2	44.2
	@								

Temperature at Port (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.58 @45	1.0 @ 45	0.82@ 2	— @ —	2114	2178	1830
Finish	4.56@ 45	1.0 @ 45	0.82 @ 2	—@ —	2121	2185	1787

589 323 45 @ 2

Innovative Furnace Data Log

Date: 12/6/90
Initials: eBe
Test: #N5

NH$_3$ Rotameter
Setting (BB height): 145
Fuel: Natural Gas
Slurry: H$_2$O
% Excess Air (measured): —

SO$_2$ Rotameter
Setting (BB height): N/A
Draft (inches of water): 0.3
Injection Port: 4th upper

NSR 1 is Acheived By feeding A 25% by wt noxot sol.

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min
BL	1.03 @ 70	8.075	7.08	3	374	0	—		
NSR2	1.03 @ 70	8.0	7.16	15	243	0	1.34		
BL	1.03 @ 70	8.1	7.14	8	375	0	—		
NSR2	1.03 @ 70	8.025	7.18	18	242	0	1.34		~~47.~~
BL	1.03 @ 70	8.1	7.16	8	378	0	—	→	47.
	@								
BL	1.03 @ 70	8.175	7.1	7	376	0	—	47.0	
NSR3	1.03 @ 70	8.0	7.16	20	175	0	2.01	47.0	
BL	1.03 @ 70	8.125	7.1	8	375	0	—	47.0	
NSR3	1.03 @ 70	8.0	7.11	20	165	0	2.01	47.0	
BL	1.03 @ 70	8.125	7.05	8	375	0	—	47.0	45.
	@								
BL	1.03 @ 70	8.25	7.0	8	375	0	—	47.0	
NSR1	1.03 @ 70	8.125	7.1	12.5	325	0	1.45	47.0	
BL	1.03 @ 70	8.125	7.1	8	375	0	—	47.0	
NSR1	1.03 @ 70	8.0	7.1	13	300	0	1.45	47.0	
BL	1.03 @ 70	8.075	7.1	8	375	0	—	47.0	47.
	@								

					Temperature at Port (°		
	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upp
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2130	224	182
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2126	2201	178

see note on back

Date: 12/7/90
Initials: EBP
Test: #NG

Innovative Furnace Data Log

NH$_3$ Rotameter
Setting (BB height): 85
Fuel: Natural GAS
Slurry: H$_2$O
% Excess Air (measured): —

SO$_2$ Rotameter
Setting (BB height): N/A
Draft (inches of water): 0.3
Injection Port: 3rd middle

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	7.0	7.86	5	393	2	—	47.0	
NSR2	1.03 @ 70	6.875	7.9	20	133	2	1.34	47.0	
BL	1.03 @ 70	6.95	7.86	7	383	3	—	47.0	
NSR2	1.03 @ 70	6.9	7.9	22	130	2	1.34	47.0	
BL	1.03 @ 70	6.925	7.86	11	390	3	—	47.0	
BL	0.97 @ 80	6.925	7.86	11	390	3	—	47.0	
NSR2	0.97 @ 80	~~6.95~~ 6.875	~~7.86~~ 7.9	17	120	3	1.34	47.0	
BL	0.97 @ 80	6.925	7.86	10	388	0	—	47.0	
BL	0.93 @ 90	6.85	7.84	11	383	0	—	47.0	
NSR2	0.93 @ 90	6.825	7.96	26	112	0	1.34	47.0	
BL	0.93 @ 90	6.825	7.88	7	375	0	—	47.0	
BL	1.03 @ 70	6.85	7.88	7	375	0	—	47.0	
NSR2	1.03 @ 70	6.775	7.96	27	120	0	1.34	47.0	
BL	1.03 @ 70	6.95	7.9	9	378	0	—	47.0	
BL	1.03 @ 70	6.975	7.8	~~2400~~ 7	375	0	—	47.0	47.9
NSR1	1.03 @ 70	6.85	7.86	25	219	0	1.4	46.7	
BL	1.03 @ 70	6.95	7.84	8	373	0	—	46.7	
NSR1	1.03 @ 70	6.875	7.88	26	238	0	1.4	46.7	
BL	1.03 @ 70	7.0	7.8	12	376	0	—	46.7	47.0

Temperature at Port (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2083	2085	1818
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2071	2032	1703

Innovative Furnace Data Log

Date: 12/12/90
Initials CBC
Test: #N7

NH$_3$ Rotameter Setting (BB height): N_2 / Air 69 / 25
Fuel: natural Gas
Slurry: H$_2$O
% Excess Air (measured): 27.5%/55%

SO$_2$ Rotameter Setting (BB height): N/A
Draft (inches of water): 0.3
Injection Port: 3rd middle

	~~+57~~ Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	N_2 1.03 @ 70	4.825	7.44	20	370	0	—	46.8	
NSR 1	N_2 1.03 @ 70	4.7	7.48	56	108	0	1.46	46.8	
BL	N_2 1.03 @ 70	4.725	7.46	24	368	0	—	46.8	
NSR 1	N_2 1.03 @ 70	4.65	7.5	61	86	0	1.46	46.8	
BL	N_2 1.03 @ 70	4.75	7.48	30	365	0	—	46.8	
BL	1.03 @ 70	7.95	7.46	9	303	0	~~0~~ —	46.8	
NSR1	1.03 @ 70	7.9	7.5	21	155	0	1.46	46.8	
BL	1.03 @ 70	7.975	7.46	10	302	0	—	46.8	
NSR1	1.03 @ 70	7.925	7.5	21	148	0	1.46	46.8	
BL	1.03 @ 70	8.0	7.46	8	300	0	—	46.8	48.0
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Temperature at ~~Port~~ Level (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2130	2126	1850
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2124	2080	1775

Innovative Furnace Data Log

Date: 12/12/90
Initials CDC
Test: #N7 cont.

	N_2	AiR
NH_3 Rotameter Setting (BB height):	69	24

SO_2 Rotameter Setting (BB height): N/A
Fuel: NATURAL GAS
Draft (inches of water): 0.4
Slurry: H_2O
Injection Port: 3rd middle
% Excess Air (measured):

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	8.1	7.42	7	295	0	—	47.1	
NSR2	1.03 @ 70	8.0	7.48	28	51	0	1.38	47.1	
BL	1.03 @ 70	8.125	7.4	9	294	0	—	47.1	
NSR2	1.03 @ 70	8.05	7.46	29	52	0	1.38	47.1	
BL	1.03 @ 70	8.1	7.36	8	289	0	—	47.1	
BL	N_2 1.03 @ 70	5.075	7.34	12	357	0	—	47.1	
NSR2	N_2 1.03 @ 70	4.925	7.42	28	23	0	1.38	47.1	
BL	N_2 1.03 @ 70	5.0	7.4	13	360	0	—	47.1	CDC
NSR2	N_2 1.03 @ 70	4.825	7.48	52	13	0	1.38	47.1	~~47.5~~
BL	N_2 1.03 @ 70	4.95	7.38	19	355 ~~49~~ CDC	0	—	47.1	47.5
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					Temperature at Port (°F)		
	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2120	2057	1718
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2114	2036	1665

Innovative Furnace Data Log

Date: 12/12/90
Initials: eBe
Test: #N7 cont

NH_3 Rotameter Setting (BB height): N_2 | Air 67 | 24
Fuel: Natural GAS
Slurry: H_2O
% Excess Air (measured):

SO_2 Rotameter Setting (BB height): N/A
Draft (inches of water): 0.3
Injection Port: 3rd middle

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	N_2 @ 70	4.95	7.42	18	357	0	—	47.0	
NSR3	N_2 @ 70	4.75	7.48	435	3	0	2.00	47.0	
BL	N_2 @ 70	4.975	7.38	17	356	0	—	47.0	
NSR3	N_2 @ 70	4.925	7.46	155	4	0	2.00	47.0	
BL	N_2 1.03 @ 70	4.95	7.36	21	355	0	—	47.0	
BL	1.03 @ 70	8.075	7.36	11	298	0	—	47.0	
NSR3	1.03 @ 70	8.0	7.42	48	27	0	2.00	47.0	
BL	1.03 @ 70	8.125	7.26	12	295	0	—	47.0	
NSR3	1.03 @ 70	7.925	7.48	51	25	0	2.00	47.0	
BL	1.03 @ 70	8.075	7.36	12	297	0	—	47.0	46.8
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Temperature at ~~Port~~ Level (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2112	2033	165
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2111	2024	1626

Innovative Furnace Data Log

Date 12 14 90
Initials CBC
Test: #N8

NH$_3$ Rotameter Setting (BB height): 35 (New Rotameter)
Fuel: NATURAL GAS
Slurry: H$_2$O
% Excess Air (measured):

SO$_2$ Rotameter Setting (BB height): N/A
Draft (inches of water): 0.3
Injection Port: 3rd middle

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min
BL	1.03 @ 70	7.9	7.52	7	363	0	—	46.9	
NSA3	1.03 @ 70	7.8	7.6	19	42	0	2.00	46.9	
BL	1.03 @ 70	7.95	7.46	8	363	0	—	46.9	
NSR3	1.03 @ 70	7.275	7.88	24	35	0	2.00	46.9	
BL	1.03 @ 70	7.45	7.76	8	375	0	—	46.9	47.8
	@								
BL	1.03 @ 70	7.6	7.62	10	377	0	—	47.1	
NSR2	1.03 @ 70	7.475	7.72	34	48 ~~34~~ Temp	0	1.4	47.1	
BL	1.03 @ 70	7.575	7.66	9	375	0	—	47.1	
NSR2	1.03 @ 70	7.475	7.7	33	43	0	1.4	47.1	
BL	1.03 @ 70	7.575	7.62	10	375	0	—	47.1	47.0
	@								
5% BL	1.03 @ 70	7.35	7.72	23	382	0	—	46.8	
NSR1	1.03 @ 70	7.3	7.72	40	163	0	1.42	46.8	
BL	1.03 @ 70	7.325	7.66	20	380	0	—	46.8	
NSR1	1.03 @ 70	7.275	7.76	41	160	0	1.42	46.8	
BL	1.03 @ 70	7.35	7.7	20	376	0	—	46.8	46.3
	@								

Temperature at Port (°F

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upp
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2107	2120	186
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2134	2035	163

Innovative Furnace Data Log

Date: 12/14/90
Initials: eBe
Test: #N8 Cont

NH$_3$ Rotameter Setting (BB height): 25
Fuel: Natural GAS
Slurry: H$_2$O
% Excess Air (measured):

SO$_2$ Rotameter Setting (BB height): 55
Draft (inches of water): 0.4–0.5
Injection Port: 3rd middle

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	7.625	7.64	16	374	1625	—	47.1	
NSR2	1.03 @ 70	7.45	7.74	40	27	1650	1.4	47.1	
BL	1.03 @ 70	7.575	7.64	23	372	1670	—	47.1	
NSR2	1.03 @ 70	7.475	7.7	45	25	~~1650~~ 1625	1.4	47.1	
BL	1.03 @ 70	7.525	7.66	27	373	1680	—	47.1	47.0
	@								
BL	1.03 @ 70	7.55	7.66	33	373	1690	—	47.0	
NSR3	1.03 @ 70	7.375	7.8	55	12	1700	2.00	47.0	
BL	1.03 @ 70	7.4	7.8	32	373	1740	—	47.0	
NSR3	1.03 @ 70	7.275	7.9	60	11	1725	2.00	47.0	
BL	1.03 @ 70	7.2	7.86	32	378	1745	—	47.0	47.7
	@								
BL	1.03 @ 70	7.5	7.66	30	375	1700	—	46.8	
NSR1	1.03 @ 70	7.3	7.84	50	140	1725	1.42	46.8	
BL	1.03 @ 70	7.325	7.76	30	375	1725	—	46.8	
NSR1	1.03 @ 70	7.225	7.82	51	148	1710	1.42	46.8	
BL	1.03 @ 70	7.375	7.28	32	375	1715	—	46.8	46.3
	@								

Temperature at Port (°F

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2129	~~2129~~ 2060	1724
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2132	2038	1649

Innovative Furnace Data Log

Date: 12/19/90
Initials: eBC
Test: #N9

NH$_3$ Rotameter Setting (BB height): N_2 32 / Air 21
Fuel: Natural Gas
Slurry: H$_2$O
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): NA
Draft (inches of water): 0.3
Injection Port: 3rd middle

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	N_2 1.03 @ 70	4.025	7.8	5	391	0	—	47.1	
NSR2	N_2 1.03 @ 70	3.925	7.88	7	72	0	1.31	47.1	
BL	N_2 1.03 @ 70	4.075	7.8	5	388	0	—	47.1	
NSR2	N_2 1.03 @ 70	3.925	7.88	8	61	0	1.31	47.1	
BL	N_2 1.03 @ 70	4.025	7.8	6	386	0	—	47.1	
	@								
BL	1.03 @ 70	7.225	7.78	6	320	0	—	47.1	
NSR2	1.03 @ 70	7.05	7.9	11	88	0	1.31	47.1	
BL	1.03 @ 70	7.2	7.86	3	319	0	—	47.1	
NSR2	1.03 @ 70	7.1	7.94	11	83	0	1.31	47.1	
BL	1.03 @ 70	7.225	7.84	2	318	0	—	47.1	45.9
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	@								

Temperature at ~~Port~~ Level (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2235	2245	1981
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2214	2173	1907

Innovative Furnace Data Log

Date: 12/19/90
Initials: CBE
Test: # NG cont

NH_3 Rotameter Setting (BB height): N_2 32 / Air 21
Fuel: Natural GAS
Slurry: H_2O
% Excess Air (measured): –

SO_2 Rotameter Setting (BB height): N/A
Draft (inches of water): 0.4
Injection Port: 3rd middle

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	7.6	7.64	3	~~300~~ 310 cbe	0	–	46.9	
NSR3	1.03 @ 70	7.475	7.74	15	38	0	2.04	46.9	
BL	1.03 @ 70	7.6	7.6	2	309	0	–	46.9	
NSR3	1.03 @ 70	7.475	7.72	17	35	0	2.04	46.9	
BL	1.03 @ 70	7.675	7.6	2	310	0	–	46.9	
	@						~~2.04~~		
BL	N_2 1.03 @ 70	4.55	7.58	2	380	0	–	46.9	
2 NSR3	N_2 1.03 @ 70	4.3	7.72	11	25	0	2.04	46.9	
BL	N_2 1.03 @ 70	4.5	7.62	2	380	0	–	46.9	
NSR3	N_2 1.03 @ 70	4.325	7.72	12 ~~2~~ cbe	21	0	2.04	46.9	
BL	N_2 1.03 @ 70	4.475	7.6	3	381	0	–	46.9	46.5
	@								
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	@								
	@								
	@								

Temperature at ~~Port (~~ Level (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
tart	4.58 @ 45	1.0 @ 45	0.82 @ 2	– @ –	2210	2158	1886
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	– @ –	2189	2108	1795

Innovative Furnace Data Log

Date: 12/19/90
Initials PBP
Test: #N9 cont

NH$_3$ Rotameter N$_2$ | Air
Setting (BB height): 32 | 21
Fuel: Natural GAS
Slurry: H$_2$O
% Excess Air (measured): —

SO$_2$ Rotameter
Setting (BB height): N/A
Draft (inches of water): 0.4
Injection Port: 3rd middle

½

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	N$_2$ 1.03 @ 70	4.475	7.64	2	376	0	—	46.9	
NSRI	N$_2$ 1.03 @ 70	4.4	7.66	7	157	0	1.4	46.9	
BL	N$_2$ 1.03 @ 70	4.5	7.62	2	375	0	—	46.9	
NSRI	N$_2$ 1.03 @ 70	4.425	7.66	8	170	0	1.4	46.9	
BL	N$_2$ 1.03 @ 70	4.55	7.6	3	374	0	—	46.9	
	@								
BL	1.03 @ 70	7.7	7.5	4	311	0	—	46.9	
NSRI	1.03 @ 70	7.675	7.58	18	142	0	1.4	46.9	
BL	1.03 @ 70	7.75	7.56	4	309	0	—	46.9	
NSRI	1.03 @ 70	7.7	7.6	20	141	0	1.4	46.9	
BL	1.03 @ 70	7.775	~~7.6~~	4	308	0	—	46.9	46.5
	@		7.54						
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Temperature at ~~Port~~ Level (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2183	2097	177
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2173	2076	171

Innovative Furnace Data Log

Date: 11/2/91
Initials CBC
Test: #N0

NH_3 Rotameter
Setting (BB height): 46 - 47
Fuel: NAtural GAs
Slurry: H_2O
% Excess Air (measured): —

SO_2 Rotameter
Setting (BB height): N/A
Draft (inches of water): 0.5
Injection Port: 3rd middle

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	7.875	7.36	10	375		—	46.8	
NSR2	1.03 @ 70	7.775	7.48	15	135		1.4	46.8	
BL	1.03 @ 70	8.05	7.36	11	373		—	46.8	
NSR2	1.03 @ 70	7.8	7.48	17	127		1.4	46.8	
BL	1.03 @ 70	7.95	7.38	10	375		—	46.8	
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Temperature at Port (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
tart	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2203	2197	1951
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2194	2167	1917

Innovative Furnace Data Log

Date: 1/10/91
Initials CDC
Test: #N11 Cont.

NH$_3$ Rotameter Setting (BB height): 19
Fuel: Natural gas
Slurry: Terra Luttrell Ca(OH)$_2$ (20%) 18%
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 58
Draft (inches of water): 0.2
Injection Port: 3rd middle

Ca(OH)$_2$ Slurry

.35%

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	8.5	7.2	6	368	1550	|	48 (H$_2$O)	
Cals	1.03 @ 70	8.35	7.2	8	323	325	|	53 (Slurry)	
BL	1.03 @ 70	8.25	7.34	10	378	1425	|	48 (H$_2$O)	
Cals	1.03 @ 70	8.1	7.24	12	378	225	|	52.5 (Slurry)	
BL	1.03 @ 70	8.175	7.42	7	378	1415	|	47.5 (H$_2$O)	
Cals	1.03 @ 70	8.1	7.36	8	378	600	—	49.5 (Slurry)	
Cals + ~~BL~~ NSR2	1.03 @ 70	7.875	7.4	39	93	380	(25%) 2.2	49.5 (Slurry)	
~~Cals~~ BL	1.03 @ 70	8.075	7.4	9	380	1400	—	48 (H$_2$O)	
~~Cals+NSR2~~ Cals	1.03 @ 70	8.125	7.38	0	370	540	—	50 (Slurry)	
Cals + NSR2	1.03 @ 70	8.075	7.4	1	75	445	(25%) 2.2	50 (Slurry)	
BL	1.03 @ 70	8.2	7.36	0	360	1365	—	48 (H$_2$O)	
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1.42% Ca(OH)$_2$ Slurry

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	Temperature at Port (°F) 2	3	4 uppe
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ –	1912	1955	1705
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ –	1928	1897	153

Innovative Furnace Data Log

Date: 1/11/91
Initials CBE
Test: #N12

NH3 Rotameter Setting (BB height): 22
Fuel: NATURAL GAS
Slurry: Ca(OH)2 Slurry
% Excess Air (measured): —

SO2 Rotameter Setting (BB height): 75
Draft (inches of water): 0.2
Injection Port: 3rd middle

13% Ca(OH)2 Slurry

1%

[illegible] Slurry

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	(pure sol) NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	5.2	8.9	0	445	2025	—	(H_2O) 48	
Ca/S	1.03 @ 70	4.75	9.1	3	457	915	—	(Slurry) 49.8	①
Ca/S+NSR	1.03 @ 70	4.25	9.44	13	45	660	1.45	(Slurry) 49.8	
BL	1.03 @ 70	5.025	8.86	3	[illegible] ~~380~~	1900	—	(H_2O) 48.5	
Ca/S	1.03 @ 70	5.05	8.86	20 [illegible]	450	1000	—	(Slurry) 49	
Ca/S+NSR	1.03 @ 70	4.95	8.9	70	75	800	1.45	(Slurry) 49	②
BL	1.03 @ 70	5.1	8.86	20	449	1840 ~~1265~~ est	—	(H_2O) 48	
Ca/S	1.03 @ 70	5.075	8.86	20	457	1265	—	(Slurry) 48.8	
NSR+Ca/S	1.03 @ 70	4.95	8.9	70	68	~~1860~~ 1450 est	1.45	(Slurry) 48.8	③
BL	1.03 @ 70	5.075	8.86	18	448	1860	—	(H_2O) 48	
Ca/S	1.03 @ 70	5.05	8.84	20	453	1300	—	(Slurry) 48.8	④
Ca/S+NSR	1.03 @ 70	4.9	8.96	68	83	1125	1.45	(Slurry) 48.8	
BL	1.03 @ 70	5.0	8.98	18	427	1740	—	(H_2O) 48	
	@								
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Temperature at Port (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1970	1969	1664
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2080	1991	1539

Innovative Furnace Data Log

Date: 1/14/91
Initials GBC
Test: #N13

NH$_3$ Rotameter Setting (BB height): N/A
Fuel: Natural Gas
~~Slurry:~~ Sorbent: Tenn Luttrell Ca(OH)$_2$
% Excess Air (measured): ——

SO$_2$ Rotameter Setting (BB height): 52
Draft (inches of water): 0.3 – 0.4
Injection Port: 3rd middle

	Sorbent Air ~~Stage Air~~ (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (g/min)	Ending Feed Rate (g/min)
BL	1.25 @ 30	6.45	8.36	51	110	1750		——	——
Ca/S	1.25 @ 30	6.375	8.34	50	111	1155		0.023 | 3 g/min	2.72
BL	1.25 @ 30	6.425	8.36	52	111	1740		——	——
Ca/S	1.25 @ 30	6.35	8.36	52	111	1160		0.023 | 3 g/min	2.72
BL	1.25 @ 30	6.375	8.38	52	111	1775		——	——
Ca/S	1.25 @ 30	6.3	8.38	50	112	665		0.047 | 6 g/min	5.81
BL	1.25 @ 30	6.35	8.38	53	111	1750		——	——
Ca/S	1.25 @ 30	6.25	8.4	52	113	680		0.047 | 6 g/min	5.81
BL	1.25 @ 30	6.35	8.4	53	112	1750		——	——
Ca/S	1.25 @ 30	6.2	8.42	50	111	300		0.070 | 9 g/min	8.5
BL	1.25 @ 30	6.275	8.42	53	112	1675		——	——
Ca/S	1.25 @ 30	6.125	8.46	52	111	255		0.070 | 9 g/min	8.5
BL	1.25 @ 30	6.225	8.46	54	112	1675		——	——
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Temperature at Port (°F

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
tart	4.8 @ 45	1.0 @ 45	0.82 @ 2	—— @ —	2188	2212	1951
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	—— @ —	2188	2191	1919

Innovative Furnace Data Log

Date: 1/15/91
Initials ebe
Test: # N14

NH$_3$ Rotameter Setting (BB height): 22
Fuel: natural gas
Slurry: Ca(OH)$_2$ Tenn Luttrell
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 65
Draft (inches of water): 0.3 – 0.4
Injection Port: 3rd Right

19 %

		Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
	BL	1.03 @ 70	6.0	8.5	11	452	1750	—	(H$_2$O) 48	
1	Cals	@	5.975	8.5	11	458	865	—	(Slurry) 51	① 87.
1a	Cals+NSR	@	5.75	8.6	12	100	725	1.35	(Slurry) 51	〃 1.
	BL	@	5.87	8.5	5	460	1700	—	(H$_2$O) 48	
2	Cals	@	5.875	8.52	5	468	1075	—	(Slurry) 51	② ~~18~~
2a	Cals+NSR	@	5.7	8.64	10	110	925	1.35	(Slurry) 51	〃
	BL	@	5.875	8.54	4	463	1780	—	(H$_2$O) 48	
3	Cals	@	5.825	8.5	4	465	250	—	(Slurry) 51	③ 18.
3a	Cals+NSR	@	5.65	8.56	N	68	165	1.35	(Slurry) 51	〃 1.
	BL	@	5.825	8.56	4	466	1715	—	(H$_2$O) 48	
4	Cals	@	5.75	8.5	5	468	325	—	(Slurry) 51	④
4a	Cals+NSR	@	5.675	8.58	4	85	205	1.35	(Slurry) 51	〃
	BL	@	5.8	8.54	5	472	1625	—	(H$_2$O) 48	
5	Cals	@	5.75	8.5	1st ~~4~~ 4	475	650	—	(Slurry) 50.5	⑤ 16.
	Cals+NSR	@							(Slurry)	〃
	BL	@						—	(H$_2$O) 48	
	Cals	@						—	(Slurry)	
	Cals+NSR	@							(Slurry)	
	BL	@						—	(H$_2$O) 48	

Temperature at Port (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
tart	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2095	2029	1700
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2118	2018	158

Innovative Furnace Data Log

Date: 1/16/91
Initials RWG & CCB
Test: N15

NH$_3$ Rotameter
Setting (BB height): 25
Fuel: Natural Gass
Slurry: Calcium Hydroxide
% Excess Air (measured):

SO$_2$ Rotameter
Setting (BB height): 57
Draft (inches of water): 0.2-0.3
Injection Port: 3rd Right

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @70	5.75	8.5	17	410	1825	—	48(H$_2$O)	(12.5
NSR	1.03 @70	5.3	8.84	29	105	1950	1.4	48	
BL	1.03 @ 70	5.425	8.72	18	415	1990	—	48	
NSR	1.03 @ 70	5.2	8.98	33	115	~~2005~~ 1990	1.4	48	
BL	1.03 @ 70	5.225	8.94	20	423	2005	—	48	
CalS	1.03 @ 70	4.88	8.95	18	430	575	—	(Slurry) 55	
CalS+NSR	1.03 @ 70	4.5	9.2	28	175	305	1.4	(Slurry) 55	
BL	1.03 @ 70	4.55	9.26	22	445	1750	—	(H$_2$O) 48	
CalS ~~NSR~~	1.03 @ 70	4.475	9.24	20	443	500	—	Slurry 55	
CalS+NSR	1.03 @ 70	4.325	9.36	28	200	300	1.4	(Slurry) 55	
BL	1.03 @ 70	4.475	9.36	23	444	1750	—	(H$_2$O) 48	
	@								
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Temperature at Port (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.57 @ 45 psi	1 @45 psi	0.82@2 PSI	— @ —	2003	2084	1770
Finish	4.57 @ 45	1.0@45	0.82@ 2	— @ —	2024	~~2034~~ 2050	1693

Innovative Furnace Data Log

Date: 1/18/91
Initials: EBE
Test: #N16

NH$_3$ Rotameter Setting (BB height): 27
Fuel: natural GAS
Slurry: Ca(OH)$_2$ (Tenn Luttrell)
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 60
Draft (inches of water): 0.4
Injection Port: 4th upper

		Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
	BL	1.03 @ 70	5.925	8.48	12	428	1795	—	(H$_2$O) 48	
1	NSR	1.03 @ 70	5.85	8.54	24	92	1860	1.4	(H$_2$O) 48	
	BL	1.03 @ 70	5.95	8.46	14	423	1895	—	(H$_2$O) 48	
2	NSR	1.03 @ 70	5.85	8.52	27	96	1915	1.4	(H$_2$O) 48	
	BL	1.03 @ 70	5.9	8.46	14	420	1990	—	(H$_2$O) 48	
3	Cal/S	1.03 @ 70	5.725	8.52	14	430	625	—	(Slurry) 52	① 12
3a	Cal/S+NSR	1.03 @ 70	5.525	8.6	31	95	410	1.4	(Slurry) 52	
	BL	1.03 @ 70	5.85	8.54	14	427	2015	—	(H$_2$O) 48	
4	Cal/S	1.03 @ 70	5.55	8.66	16	438	700	—	(Slurry) 52	②
4a	Cal/S+NSR	1.03 @ 70	5.35	8.76	38	98	550	1.4	(Slurry) 52	
	BL	1.03 @ 70	5.5	8.78	15	440	1950	—	(H$_2$O) 48	
5	Cal/S	1.03 @ 70	5.45	8.76	18	438	1000	—	(Slurry) 52	③ 9.
5a	Cal/S+NSR	1.03 @ 70	5.325	8.84	43	70	800	1.4	(Slurry) 52	
	BL	1.03 @ 70	5.45	8.78	15	438	1990	—	(H$_2$O) 48	
	Cal/S	1.03 @ 70						—	(Slurry) 52	
	Cal/S+NSR	1.03 @ 70							(Slurry) 52	
	BL	1.03 @ 70						—	(H$_2$O) 48	
		@								

Temperature at Port (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2017	2139	1848
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	?	?	?

Innovative Furnace Data Log

Date: 1/21/91
Initials EBC
Test: # N17

NH$_3$ Rotameter
Setting (BB height): 22
Fuel: Natural Gas
Slurry: Ca(OH)$_2$ Tenn Lmt
% Excess Air (measured): –

SO$_2$ Rotameter
Setting (BB height): 62
Draft (inches of water): 0.2
Injection Port: 4th upper

		Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min
	BL	1.03 @ 70	5.15	8.96	15	433	2050	–	48.2	
10	NSR	1.03 @ 70	5.075	9.0	23	90	2085	1.4		
	BL	1.03 @ 70	5.275	8.82	20	454	2105	–		
11	NSR	1.03 @ 70	5.2	9.0	24	73	2125	1.4		
	BL	1.03 @ 70	5.35	8.92	23	425	2160	—		
6	Ca/S	1.03 @ 70	5.275	8.96	24	443	940	—	(Slurry) 47.5	①
6a	Ca/S+NSR	1.03 @ 70	5.0	9.04	34	110	690	1.4	(Slurry) 47.5	
	BL	1.03 @ 70	5.225	8.96	25	440	1885	—	(H$_2$O) 48.2	
7	Ca/S	1.03 @ 70	5.13	9.0	25	445	900	—	(Slurry) 47.5	②
7a	Ca/S+NSR	1.03 @ 70	4.99	9.2	35	150	300	1.4	(Slurry) 47.5	
	BL	1.03 @ 70	5.075	9.0	30	438	1890	–	(H$_2$O) 48.2	
8	Ca/S	1.03 @ 70	5.1	9.02	30	442	280	—	(Slurry) 46	③
8a	Ca/S+NSR	1.03 @ 70	4.95	9.04	46	100	130	1.4	(Slurry) 46	
	BL	1.03 @ 70	5.06	9.0	30	430	1813	–	(H$_2$O) 48	
9	Ca/S	1.03 @ 70	5.05	8.96	33	430	475	–	(Slurry) 46	④
9a	Ca/S+NSR	1.03 @ 70	4.875	9.04	51	100	160	1.4	(Slurry) 46	
	BL	1.03 @ 70	5.125	8.95	30	430	1800	—	(H$_2$O) 48	
		@								

Temperature at ~~Port~~ Level (°F

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upp
tart	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ –	2128	2259	1966
Finish	4.6 @ 45	1.0 @ 45	.82 @ 2	— @ –	2221	2101	186

Innovative Furnace Data Log

Date: 1 /22/91
Initials CBC
Test: #N18

NH$_3$ Rotameter Setting (BB height): N/A
Fuel: NAtural GAS
Slurry: Dry Sorbant Ca(OH)$_2$ Tenlant
% Excess Air (measured):

SO$_2$ Rotameter Setting (BB height): 60
Draft (inches of water): 0.2
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	Feeder setting ~~NO OUT Feed Rate (ml/min)~~	Starting Feed Rate (g/min) ~~(ml/min)~~	Ending Feed Rate (g/ ~~(ml/min)~~
BL	1.25 @ 30	5.375	8.92	15	88	1875	—	—	—
Ca/S	1.25 @ 30	5.35	8.98	15	87	1325	0.024	3	2.88
BL	1.25 @ 30	5.375	8.96	16	86	1885	—	—	—
Ca/S	1.25 @ 30	5.25	8.96	15	87	1330	0.024	3	2.88
BL	1.25 @ 30	5.2	8.98	15	87	1930	—	—	—
Ca/S	1.25 @ 30	5.1	9.04	15	89	780	0.048	6	5.95
BL	1.25 @ 30	5.15	9.06	15	88	1900	—	—	—
Ca/S	1.25 @ 30	4.975	9.08	16	89	790	0.048	6	5.95
BL	1.25 @ 30	5.075	9.1	15	87	1925	—	—	—
Ca/S	1.25 @ 30	4.95	9.12	14	90	475	0.071	9	8.78
BL	1.25 @ 30	5.025	9.08	14	88	1920	—	—	—
Ca/S	1.25 @ 30	4.85	9.14	15	89	340	0.071	9	8.78
BL	1.25 @ 30	4.95	9.14	15	89	1915	—	—	—
	@								
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	@								

Temperature at ~~Port~~ # sections (°F

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2093	2212	194
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2062	2167	1880

Innovative Furnace Data Log

Date: 1/28/91
Initials CBC
Test: #N19

NH_3 Rotameter Setting (BB height): N/A
Fuel: NATURAL GAS
~~Slurry~~: Dry I-T of Team Lutrell/$Ca(OH)_2$
% Excess Air (measured):

SO_2 Rotameter Setting (BB height): 41
Draft (inches of water): 0.2 - 0.3
Injection Port: 4th LOWER

	Sorbant Air ~~Stage Air~~ (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	Feeder setting ~~NO_x OUT~~ ~~Feed Rate~~ ~~(ml/min)~~	Starting Feed Rate (g/min)	Ending Feed Rate (g/min)
BL	1.25 @ 30	5.975	8.5	19	61	1855	—		
Ca/S	@	5.875	8.54	24	60	1275	0.023	3	3.05
BL	@	5.95	8.48	18	61	1840	—		
Ca/S	@	5.95	8.5	23	63	1245	0.023	3	3.05
BL	@	5.975	8.5	18	62	1835	—		
Ca/S	@	5.85	8.52	27	63	725	0.047	6	6.25
BL	@	5.95	8.5	16	63	1805	—		
Ca/S	@	5.825	8.52	26	69	705	0.047	6	6.25
BL	@	5.825	8.52	19	63	1780	—		
Ca/S	@	5.8	8.54	27	66	290	0.070	9	9.28
BL	@	5.85	8.5	19	64	1745	—		
Ca/S	@	5.75	8.56	25	68	275	0.070	9	9.28
BL	@	5.825	8.56	19	68	1745	—		
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	@								
	@								
	@								
	@								

Temperature at Level ~~Port~~ (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
tart	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1755	1925	1631
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1867	2020	1690

Innovative Furnace Data Log

Date: 1/28/91
Initials ebr
Test: #N20

NH$_3$ Rotameter Setting (BB height): N/A
Fuel: NAtural GAS
~~Slurry:~~ Dry Inj. of Tennlutrell Ca(OH)$_2$
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 37/38
Draft (inches of water): 0.2
Injection Port: 5th

	Sorbent ~~Stage~~ Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	Feedersetting ~~NO$_x$ OUT~~ ~~Feed Rate~~ ~~(ml/min)~~	Starting Feed Rate (g/min)	Ending Feed Rate (g/min)
BL	1.25 @ 30	5.85	8.56	24	64	1815	—	—	—
Cals	@	5.825	8.58	33	65	1250	0.023	3	3.05
BL	@	5.85	8.6	23	64	1765	—	—	—
Cals	@	5.775	8.6	34	64	1250	0.023	3	3.05
BL	@	5.775	8.62	23	65	1770	—	—	—
cals	@	5.725	8.62	44	68	725	0.047	6	6.25
BL	@	5.775	8.6	24	64	1745	—	—	—
cals	@	5.675	8.6	44	67	640	0.047	6	6.25
BL	@	5.7	8.6	25	68	1710	—	—	—
cals	@	5.575	8.64	55	71	275	0.070	9	9.28
BL	@	5.675	8.6	24	68	1660	—	—	—
Cals	@	5.6	8.62	51	68	255	0.070	9	9.28
BL	↓ @ ↓	5.625	8.64	27	70	1645	—	—	—
	@								
	@								
	@								
	@								
	@								

Temperature at ~~Port~~ Level (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1900	2050	1716
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1952	2099	1767

Innovative Furnace Data Log

Date: 1/30/91
Initials CBC
Test: #N21

NH$_3$ Rotameter Setting (BB height): N/A
Fuel: natural Gas
Slurry: Tenn Luttrell Ca(OH)$_2$ Dry Inj.
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 35
Draft (inches of water): 0.1
Injection Port: 6th

	Sorbent ~~Stage~~ Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	Feeder Setting ~~NO OUT~~ ~~Feed~~ Rate ~~(ml/min)~~	Starting Feed Rate (g/min)	Ending Feed Rate (g/min)
BL	1.25 @ 30	4.45	9.32	22	81	2000	—		
Cals	@	4.325	9.38	20	82	1315	0.023	3	
BL	@	4.375	9.4	20	83	1890	—		
Cals	@	4.25	9.38	29	84	1265	0.023	3	
BL	@	4.275	9.44	20	84	1855	—		
Cals	@	4.0	9.56	35	84	560	0.047 ~~0.023~~ CBC	6	
BL	@	BASE Line would not come					—		
cals	@	back up - blew line out					0.047	6	
BL	@	4.2	9.5	19	82	1850	—		
cals	@	4.1	9.52	33	83	690	0.047	6	
BL	@	4.125	9.52	18	84	1795	—		
cals	@	4.05	8.5	33	84	615	0.047	6	
BL	@	4.1	9.48	19	83	1750	—		
BL	@	4.15	9.46	18	84	1765	—		
cals	@	3.95	9.5	39	85	195	0.070	9	
BL	@	4.1	9.48	18	83	1670	—		
cals	@	3.95	9.5	36	84	150	0.070	9	
BL	@	4.025	9.48	18	83	1625	—		

Temperature at Port (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2100	2253	1988
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2072	2226	1965

Innovative Furnace Data Log

Date: 1/3/91
Initials CBC
Test: #N22

NH$_3$ Rotameter Setting (~~BB~~ SS height): 93
Fuel: natural gas
Slurry: $Ca(OH)_2$ Tenn Luttrell
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 57
Draft (inches of water): 0.3
Injection Port: 4th lower

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03@80	3.8	9.3	18	473	2100	—	48	
NSR	@	3.475	9.5	34	345	2110	1.4	48	
BL	@	3.6	9.4	20	450	2150	—	48	
NSR	@	3.45	9.48	37	323	2115	1.4	48	
BL	@	3.575	9.46	20	453	2130	—	48	
Calcs	@	3.45	9.48	22	465	630	—	(Slurry) 54.5	
Calcs+NSR	@	3.3	9.57	34	370	400	1.4	(Slurry) 54.5	
BL	@	3.275	9.62	21	440	1750	—	48	
	@								
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	@								
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	@								
	@								
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lurry setting $(54.5 \frac{ml}{min})(1.08 \frac{g}{ml})(.1758) = 10.35 \frac{g}{min}$ $Ca(OH)_2$ Slurry

Temperature at Level (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.58 @45	1.0 @45	0.82@ 2	— @ —	2021	2193	1934
Finish	4.58@ 45	1.0 @ 45	0.82@ 2	— @ —	2005	2174	1917

Innovative Furnace Data Log

Date: 2/5/91
Initials eBE
Test: #N23

NH$_3$ Rotameter Setting (~~BB~~ 33 height): 91
Fuel: natural gas
Slurry: Ca(OH)$_2$ Tenn Lmt
% Excess Air (measured):

SO$_2$ Rotameter Setting (BB height): 55
Draft (inches of water): 0.2
Injection Port: 4th lower

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	3.05	9.75	42	493	2090	—	48	
NSR	@	3.075	9.88	62	325	2100	1.4		
BL	@	3.2	9.8	44	495	2120	—		
NSR	@	3.0	9.92	65	328	2135	1.4		
BL	@	3.15	9.86	46	500	2155	—	↓	
Ca/S	@	3.1	9.78	47	488	650	—	(slurry) 52.1	
Ca/S+NSR	@	2.825	9.88	60	370	490	1.4	(slurry) 52.1	
BL	@	3.1	9.86	44	485	1675	—	48	
Ca/S	@						—	(slurry) 52.1	
Ca/S+NSR	@						1.4	(slurry) 52.1	
BL	@						—	48	
	@								
	@								
	@								
	@								
	@								
	@								
	↓ @ ↓								

$(52.1 \frac{ml}{min})(1.08 \frac{g}{ml})(.1154) = 6.49$ g/min Ca(OH)$_2$ Slurry

Temperature at Port (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
tart	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2019	2188	1922
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	—	—	-

Innovative Furnace Data Log

Date: 2/7/91
Initials EBC
Test: #N24

NH$_3$ Rotameter Setting (BB height): 31
Fuel: Natural GAS
Slurry: Ca(OH)$_2$ Tenn Lot
% Excess Air (measured):

SO$_2$ Rotameter Setting (BB height): ~~68~~ EBC 63
Draft (inches of water): 0.2-0.3
Injection Port: 2nd Right

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	5.1	8.96	8	485	1900	—	48	
NSR	@	5.0	9.0	12	550	1915	1.4	48	
BL	@	5.125	9.0	10	483 ~~548~~ ~~510~~	~~1935~~ 1925	—	48	
NSR	@	4.95	9.1	18	548	1955	1.4	48	
BL	@	5.1	9.02	12	489	1975	—	48	
Ca/S	@	4.975	9.02	12000	475	760	—	(Slurry) 50.5	①
Ca/S+NSR	@	4.95	9.06	11	573	625	1.4	(Slurry) 50.5	①
BL	@	5.45	8.76	10	460	2075	—	48	
Ca/S	@	5.425	8.78	10	460	600	—	(Slurry) 50.5	①
Ca/S+NSR	@	5.25	8.88	10	580	425	1.4	(Slurry) 50.5	①
BL	@	5.375	8.88	11	461	2025	—	48	
Ca/S	@	5.525	8.7	15	475	975	~~1.4~~	(Slurry) 49.5	② 9.5
Ca/S+NSR	@	Slurry	kept		plugging		— 1.4	(Slurry) 49.5	
BL	@						—	48	
Ca/S	@							(Slurry) 49.5	
Ca/S+NSR	@							(Slurry) 49.5	
BL	@							48	
	✓ @ ✓								

#1 Slurry setting $(50.5 \frac{ml}{min})(1.10 \frac{g}{ml})(.1432) = 7.95 \frac{g}{min}$ Ca(OH)$_2$ Slurry
#2 Slurry setting $(49.5 \frac{ml}{min})(1.08 \frac{g}{ml})(.0950) = 5.08 \frac{g}{min}$ Ca(OH)$_2$ ~~Slurry~~

					Temperature at ~~Port~~ Section (°F)		
	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
.art	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1910	2104	1939
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1817	2007	1811

Innovative Furnace Data Log

Date: 2/8/91
Initials CBC
Test: #N25

NH$_3$ Rotameter
Setting (BB height): 28
Fuel: Natural GAS
Slurry: Ca(OH)$_2$ Tenn Lmt
% Excess Air (measured):

SO$_2$ Rotameter
Setting (BB height): 74/75
Draft (inches of water): 0.3-0.4
Injection Port: 2nd Right

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	5.2	9.0	13	440	1935	—	48	9.3
NSR	@	5.1	9.2	22	405	1990	1.4		
BL	@	5.175	9.2	20	~~398~~ 400	2035	—		
NSR	@	4.975	9.3	24	398	2050	1.4		
BL	@	5.1	9.24	19	451	2075	—		
Cals	@	5.1	9.24	17	455	1225	—	(Slurry) 43	
Cal Stage	@	4.875	9.3	21	530	1105	1.4	(Slurry) 43	
BL	@	5.35	8.84	19	445	1915	—	48	
Cals	@	5.325	8.94	19	438	1130	—	(Slurry) 43	
Cal Stage R	@	5.125	9.08	19	495	1000	1.4	(Slurry) 43	
BL	@	5.35	8.96	17	439	1850	—	48	
	@								
	@								
	@								
	@								
	@								
	@								
	@								

Slurry Setting (43 g/min)(1.08 g/ml)(.0936) = 4.35 g/min Ca(OH)$_2$

Temperature at ~~Port~~ Level (°F

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
art	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @	1888	2050	1869
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @	1811	1963	1782

CBC

Innovative Furnace Data Log

Date: 2/11/91
Initials eBC
Test: #N26

NH$_3$ Rotameter Setting (BB height): 60
Fuel: natural Gas
Slurry: Ca(OH)$_2$ Ternlut.
% Excess Air (measured):

SO$_2$ Rotameter Setting (BB height): 66
Draft (inches of water): 0.4
Injection Port: 3rd middle

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	5.35	8.9	15	433	1915	—	48	
NSR	@	5.275	8.96	20	215	1930	1.4		
BL	@	5.45	8.86	13	430	1945	—		
NSR	@	5.35	8.98	24	205	1970	1.4		
BL	@	5.4	8.92	21	432	2015	—		
Ca/S	@	5.35	8.88	19	428	1260	—	(slurry) 48.5	① 9.4
Ca/S+NSR	@	5.175	8.96	22	300	775	1.4	(slurry) 48.5	①
BL	@	5.325	8.9	20	430	1975	—	48	
Ca/S ~~+NSR~~	@	5.35	8.94	18	425	1100	—	(slurry) 48.5	①
Ca/S+NSR	@	5.125	8.98	20	310	900	1.4	(slurry) 48.5	①
BL	@	5.025	9.06	17	440	1975	—	48	
Ca/S	@	5.1	9.0	15	450	875	—	(slurry) 47	② 11.4
Ca/S+NSR	@	4.925	9.1	16	325	750	1.4	(slurry) 47	②
BL	@	4.95	9.08	15	455	2050	—	48	
Ca/S	@	5.025	9.06	15	452	1000	—	(slurry) 47	②
Ca/S+NSR	@	4.85	9.1	19	325	850	1.4	(slurry) 47	②
BL	@	4.85	9.16	15	450	2200	—	48	
	@								

Slurry setting #1 (48.5 ml/min)(1.07 g/ml)(.0940) = 4.88 g/min Ca(OH)$_2$ Slurry
Slurry setting #2 (47 ml/min)(1.09 g/ml)(.1149) = 5.88 g/min Ca(OH)$_2$ Slurry

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
.art	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	2018	2123	1906
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1948	1982	1705

Innovative Furnace Data Log

Date: 2/12/91
Initials ebe
Test: #N27

NH$_3$ Rotameter
Setting (BB height): N/A
Fuel: Natural Gas
Slurry: Dry Inj Ca(OH)$_2$
% Excess Air (measured):

SO$_2$ Rotameter
Setting (BB height): 54
Draft (inches of water): 0.4
Injection Port: 3rd middle

	~~Stage~~ Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	Feeder setting ~~NO OUT~~ ~~Feed Rate~~ ~~(ml/min)~~	Starting Feed Rate (~~ml~~ g/min)	Ending Feed Rate (~~ml~~ g/min)
BL	1.25 @ 30	5.225	8.98	11	78	1965	—	—	—
Cals	@	5.1	9.1	11	78	1575	0.023	3	
BL	@	5.15	9.06	10	77	2110	—	—	—
Cals	@	5.125	9.08	11	78	1625	0.023	3	
BL	@	5.125	9.08	11	78	2100	—	—	—
Cals	@	5.0	9.12	11	78	1215	0.047	6	
BL	@	5.1	9.12	11	78	2120	—	—	—
Cals	@	5.025	9.14	10	77	1250	0.047	6	
BL	@	5.05	9.14	10	77	2150	—	—	—
Cals	@	4.85	9.22	9	79	775	0.070	9	
BL	@	4.95	9.22	10	78	2130	—	—	—
Cals	@	4.825	9.24	10	77	800	0.070	9	
BL	@	4.875	9.2	10	77	2120	—	—	—
	@								
	@								
	@								
	@								
	@								

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
art	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1863	2032	1868
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1846	2014	1859

Innovative Furnace Data Log

Date: 2/13/91
Initials ebc
Test: #N28

NH$_3$ Rotameter Setting (BB height): N/A
Fuel: NATURAL GAS
Slurry: Dry Inj. Ca(OH)$_2$ (Terra Lent)
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 51
Draft (inches of water): 0.3–0.4
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	feeder Setting ~~NO~~$_x$ OUT ~~Feed~~ Rate ~~(ml/min)~~	Starting Feed Rate (~~ml~~/min)	Ending Feed Rate (~~ml~~/min)
BL	1.25 @ 30	5.35	8.98	12	81	2025	—	—	—
Cals	@	5.25	9.0	12	82	1400	0.023	3	
BL	@	5.3	9.0	13	81	2050	—	—	—
Cals	@	5.225	9.02	12	82	1465	0.023	3	
BL	@	5.275	9.04	13	83	2090	—	—	—
Cals	@	5.125	9.08	12	82	800	0.047	6	6.01
BL	@	5.175	9.08	13	82	2060	—	—	—
Cals	@	5.075	9.12	13	83	815	0.047	6	6.01
BL	@	5.1	9.12	13	82	2110	—	—	—
Cals	@	4.975	9.18	12	83	375	0.070	9	
BL	@	5.0	9.18	12	84	2100	—	—	—
Cals	@	4.875	9.22	11	83	375	0.070	9	
BL	@	4.975	9.2	11	84	2140	—	—	—
	@								
	@								
	@								
	@								
	@								

Temperature at ~~Port~~ section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1798	2007	1755
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1797	2024	1754

Innovative Furnace Data Log

Date: 2/13/91
Initials EBC
Test: #N29

NH$_3$ Rotameter Setting (BB height): 61
Fuel: Natural Gas
Slurry: Ca(OH)$_2$ Tenn Lmt
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 49
Draft (inches of water): 0.3
Injection Port: 3rd middle

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	5.25	8.86	11	465	1945	—	48	15.53
NSR	@	5.25	8.92	16	252	1960	1.4		
BL	@	5.25 ~~5.075~~	8.8	13	466	1975	—		
NSR	@	5.225	8.8	20	235	1965	1.4		
BL	@	5.35	8.76	12	461	1990	—		
Ca/S	@	5.425	8.68	12	463	525	—	(Slurry) 49.8	
Ca/S+NSR	@	5.325	8.78	17	~~266~~ 256	285	1.4	(Slurry) 49.8	
BL	@	5.1	9.0	13	455	1905	—	48	
Ca/S	@	5.1	9.0	10	450	600	—	(Slurry) 49.8	
Ca/S+NSR	@	5.0	8.96	15	300	360	1.4	(Slurry) 49.8	
BL	@	5.225	8.86	13	473	1875	—	48	
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	@								
	@								
	@								
	@								

Slurry Setting (49.8 ml/min)(1.09 g/ml)(.1553) = 8.43 g/min Ca(OH)$_2$ Slurry

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	Temperature at ~~Port~~ Section (°F) 2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1786	1958	1734
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1758	1919	1689

Innovative Furnace Data Log

Date: 2 / 14 / 91
Initials EBC
Test: ~~EBC~~ #N 30

NH$_3$ Rotameter
Setting (BB height): 21
Fuel: Natural GAS
Slurry: Ca(OH)$_2$ Tenn Lmt.
% Excess Air (measured):

SO$_2$ Rotameter
Setting (BB height): 46
Draft (inches of water): 0.3
Injection Port: 2nd Right

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	4.625	~~[illegible]~~ 9.38	12	468	1875	—	48	
Cals	@	4.475	9.38	11	470	490	—	(Slurry)	
Cals+NSR	@	4.325	9.5	13	580	~~1925~~ 250	1.4	(Slurry)	14.25
BL	@	4.475	9.5	10	470	1925	—	48	
Cals	@	4.375	9.52	11	470	475	—	(Slurry) 48.2	
Cals+NSR	@	4.2	9.58	12	660	165	1.4	(Slurry) 48.2	
BL	@	4.325	9.5	12	473	1990	—	48	
Cals	@	4.275	9.52	10	468	550	—	(Slurry) 48.2	
Cals+NSR	@	4.075	9.56	11	500	275	1.4	(Slurry) 48.2	
BL	@	4.3	9.62	11	471	1925	—	48	
	@								
	@								
	@								
	@								
	@								
	@								
	@								
	@								

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
rt	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1699	1963	1827
rinish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1597	1850	1717

15.7

Innovative Furnace Data Log

Date: 2/15/91
Initials ebc
Test: #N 31

NH$_3$ Rotameter
Setting (~~BB~~ 35 height): ~~8~~ ebc 75
Fuel: Natural GAS
Slurry: Ca(OH)$_2$ (Tenn Lnt)
% Excess Air (measured): —

SO$_2$ Rotameter
Setting (BB height): 68
Draft (inches of water): ebc ~~0.4-0.5~~ 0.2-0
Injection Port: 4th Lower

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	4.0	ebc ~~5~~9.08	15	473	2100	—	ebc ~~18~~.47.8	18.2
Cal/s	@	3.95	9.28	16	480	500	—	(Slurry) 50	
Cal/s + NSR	@	3.725	9.38	24	240	175	1.4	(Slurry) 50	
BL	@	3.925	9.36	18	473	2040	—	47.8	
Cal/s	@	3.875	9.3	17	482	325	—	(Slurry) 50	
Cal/s + NSR	@	3.7	9.42	29	215	145	1.4	(Slurry) 50	
BL	@	4.4	9.0	17	438	200	—	47.8	
NSR	@	4.325	9.12	50	100	2090	1.4	47.8	
BL	@	4.425	9.04	18	445	2105	—	47.8	
NSR	@	4.325	9.16	57	98	2120	1.4	47.8	
BL	@	4.425	9.08	19	441	2120	—	47.8	
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Slurry Setting (50 ml/min)(1.14 g/ml)(.1824) = 10.40 g/min Ca(OH)$_2$ Slurry

Temperature at ~~Port~~ station (°F

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
tart	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1812	2112	1920
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1804	2096	1900

Innovative Furnace Data Log

Date: 2/25/91
Initials CBC
Test: #N32

NH$_3$ Rotameter
Setting (BB height): 38
Fuel: NATURAL GAS
Slurry: CaCO$_3$ (AS REC.) Tennant
% Excess Air (measured):

SO$_2$ Rotameter
Setting (BB height): 49
Draft (inches of water): 0.2
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03@70	4.325	9.58	20	463	1875	—	48	12.96
CalS	@	4.2	9.98	20	445	1150	—	(Slurry) 49	
CalS+NSR	@	4.1	10.06	29	300	~~[illegible]~~ 1150	1.4	(Slurry) 49	
BL	@	4.3	10.0	21	435	1995	—	48	
CalS	@	4.225	10.0	21	435	1175	—	(slurry) 49	Reading Be Blow Back
CalS ~~CalS+NSR~~	@	4.1	10.1	21	450	1260	~~1.4~~ CBC	(slurry) 49	Reading A Blow Back
+NSR ~~BL~~	@	3.975	10.26	31	245	1170	1.4 —	~~48~~ (Slurry) 49	
BL	@	4.225	9.68	19	455	1955	—	48	
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(49 ml/min)(1.11 g/ml)(~~.1274~~ CBC (.1296)) = ~~6.93~~ CBC 7.05 ~~7.05~~ g/min CaCO$_3$ Slurry

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58@ 45	1.0 @45	0.82@ 2	— @ —	1813	2033	1775
Finish	4.58 @ 45	1.0 @ 45	0.82@ 2	— @ —	1810	2017	1731

Innovative Furnace Data Log

Date: 2/27/91
Initials CBE
Test: #N33

NH_3 Rotameter Setting (BB height): 43.5
Fuel: Natural Gas
Slurry: $CaCO_3$ (As Received) Tanm wt
% Excess Air (measured): —

SO_2 Rotameter Setting (BB height): 54
Draft (inches of water): 0.5
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	5.425	9.0	17	450	1895	—	48	
Ca/S	↓ @ ↓	5.225	9.5	18	430	930	—	(S) 50	①
Ca/S+NSR	@	5.125	9.6	28	260	900	1.4	(S) 50	①
BL	@	5.375	9.04	18	448	1925	—	48	
Ca/S	@	5.225	9.52	17	428	1000	—	(S) 50	①
Ca/S+NSR	@	5.1	9.6	31	228	980	1.4	(S) 50	①
BL	@	5.25	9.04	18	445	1920	—	48	
Ca/S	@	5.2	9.36	19	424	1475	—	(S) 50	②
Ca/S+NSR	@	5.1	9.4	34	227	1490	1.4	(S) 50	②
BL	@	5.2	9.1	17	446	1970	—	48	
Ca/S	@						—	(S)	
Ca/S+NSR	@						1.4	(S)	
BL	↓ @ ↓						—	48	
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	@								

Slurry setting #1 $(50 \frac{ml}{min})(1.12 \frac{g}{min})(.1446) = 8.10 \frac{g}{min}$ $CaCO_3$ Slurry

Slurry setting #2 $(50 \frac{ml}{min})(1.06 \frac{g}{min})(.0813) = 4.31 \frac{g}{min}$ $CaCO_3$ Slurry

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	Temperature at ~~Port~~ Section (°F) 2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1787	2002	1705
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1705	1992	1681

Innovative Furnace Data Log

Date: 2/28/91
Initials: CBC
Test: #N34

NH$_3$ Rotameter Setting (BB height): 43
SO$_2$ Rotameter Setting (BB height): 58
Fuel: Natural Gas
Draft (inches of water): 0.4
Slurry: CaCO$_3$ (AB Rec) [illegible]
Injection Port: 4th upper
% Excess Air (measured): —

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 170	5.125	9.18	15	467	1925	—	48	
Ca/S	@	~~3.8~~ 4.25	9.52	16	461	1920	—	(5) 49	
Ca/S+NSR	@	4.6	9.68	27	275	1400	1.4	(5) 49	
BL	@	4.7	9.38	15	475	2150	—	48	
Ca/S	@	4.6	9.6	15	440	1690	—	(5) 49	
Ca/S+NSR	@	4.475	9.7	23	315	~~1945~~ 1680	1.4	(5) 49	
BL	@	4.625	9.38	15	445	2250	—	48	
Ca/S	@	4.575	9.7	18	435	1725	—	(5) 49	
Ca/S+NSR	@	4.425	9.82	27	294	1750	1.4	(5) 49	
BL	@	4.6	9.5	18	468	2275	—	48	
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Slurry setting (49 $\frac{ml}{min}$)(1.06 g/ml)(.0809) = 4.20 g/min CaCO$_3$ Slurry

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	Temperature at ~~Port~~ section (°F) 2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1788	2018	1781
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1789	2005	1732

Innovative Furnace Data Log

Date: 3/1/91
Initials CBC
Test: #N35

NH$_3$ Rotameter
Setting (BB height): N/A
Fuel: NAtural gas
Dry Sorbent ~~Slurry~~: CaCO$_3$ (As Recived) Tenn Lmt.
% Excess Air (measured): —

SO$_2$ Rotameter
Setting (BB height): 28
Draft (inches of water): 0.3 -> 0.4
Injection Port: 5th Level

	Sorbent ~~Stage~~ Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	Feeder Setting ~~NO$_x$ OUT~~ ~~Feed Rate~~ ~~(ml/min)~~	Starting Feed Rate (g/min)	Ending Feed Rate (g/min)
BL	1.25 @ 30	5.1	9.3	20	66	1900	—	—	—
Cals	@	5.05	9.58	21	68	1540	0.011	4.05	4.01
BL	@	5.075	9.38	20	68	1920	—	—	—
Cals	@	5.0	9.62	20	67	1525	0.011	4.05	4.01
BL	@	5.05	9.42	19	68	1875	—	—	—
Cals	@	4.975	9.8	20	67	1165	0.022	8.11	7.82
BL	@	5.0	9.48	19	67	1865	—	—	—
Cals	@	4.95	9.88	21	67	1135	0.022	8.11	7.82
BL	@	4.975	9.42	20	68	1870	—	—	—
Cals	@	4.9	10.02	23	66	810	0.033	12.16	11.88
BL	@	4.975	9.52	20	68	1865	—	—	—
Cals	@	4.875	10.06	23	67	775	0.033	12.16	11.88
BL	@	4.95	9.6	18	68	1820	—	—	—
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	@								
	@								

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
tart	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1819	2077	1856
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	1829	2088	1867

Innovative Furnace Data Log

Date: 3/22/91
Initials EBE
Test: #N36

NH$_3$ Rotameter Setting (BB height): 30
Fuel: natural GAS
Slurry: Ca(OH)$_2$ Tenn [illegible]
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 44
Draft (inches of water): 1.0
Injection Port: 4th Lower

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	7.6	7.8	15	402	1625	—	48	18.63
Cals	@	7.225	7.9	20	412	170	—	(S) 43	
Cals+NSR	@	6.95	7.98	70	68	75	1.37	(S) 43	
BL	@ 1.125	~~4.675~~	7.96	19	410	1610	—	48	
Cals	@	7.00	7.94	30	420	225	—	(S) 43	
Cals slow & Br. ~~Cals+NSR~~	@	7.075	7.88	25	412	275	—	(S) 43	
~~BL~~ Cals+NSR	@	6.95	7.90	83	89	125	1.37	~~48~~ (S) 43	
BL	@	7.1	7.92	22	415	1525	—	48	
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EBE
Slow break through SO$_2$ Line cals point

Slurry setting (43 ml/min)(1.12 g/ml)(.1863) = 8.97 g/min Ca(OH)$_2$ slurry

Temperature at ~~Port~~ section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
tart	458 @ 45	1.0 @45	0.82@ 2	— @ —	Burned	2225	1987
Finish	4.58 @ 45	1.0 @45	0.82@ 2	— @ —	out	2243	1898

Innovative Furnace Data Log

Date: 3 27 91
Initials cbc
Test: #N37

NH_3 Rotameter	SO_2 Rotameter
Setting (BB height): 40	Setting (BB height): 40
Fuel: Natural Gas	Draft (inches of water): 0.8 – 1.0
Slurry: $Ca(OH)_2$ Tenn Lime	Injection Port: 4th Lower
% Excess Air (measured): —	

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	8.625	7.06	25	363	1505	—	48	
NSR	@	8.575	7.10	75	250	1500	1.4		12.6
BL	@	8.5	7.08	28	355	1525	—		
BL ~~NSR~~	@	8.5	7.10	35	380	1600	~~1.4~~		
NSR ~~BL~~	@	8.425	7.20	85	250	1640	— 1.4		
BL ~~Ca/S~~	@	8.35	7.18	37	380	1650	—		
Ca/S ~~NSR~~	@	8.125	7.20	45	395	825	—	(S) 49	
Ca/S+NSR ~~BL~~	@	8.125	7.22	100	240	650	1.4	(S) 49	
~~Ca/S~~ BL	@	8.125	7.32	40	390	1575	—	48	
~~Blowback~~ Ca/S	@	7.5	7.50	70	405	800	—	(S) 49	
Ca/S ~~NSR~~	@	8.55	7.02	42	380	750	~~1.4~~	(S) 49	Little Blow BACK
~~BL~~	@	8.475	7.00	45	382	900	—	~~48~~ (S) 49	4
Ca/S ~~BL~~	@	7.85	7.40	55	400	725	—	(S) 49	BACK
Ca/S	@	8.00	7.28	55	394	675	—	(S) 49	Empty Ash pot
Ca/S ~~BL~~	@	7.775	7.42	55	400	700	—	(S) 49	Little Blow BACK
BL	@	7.625	7.66	45	405	1520	—	48	
	@								
	@								

9/4/92 4.58

Temperature at ~~End~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
art	2.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2042	1680
Finish	2.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2177	1801

Innovative Furnace Data Log

Date: 3/28/91
Initials ebe
Test: ~~4~~N3R

NH$_3$ Rotameter Setting (~~BB~~ 35 height): 80
Fuel: natural gas
Slurry: Ca(OH)$_2$ Tenn Int
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): ~~40~~ ebe 35
Draft (inches of water): ~~1.2~~ ebe 1.0
Injection Port: 5th

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	9.725	6.26	4	213	1290	—	48.2	(15.98
Ca/S	@	9.075	6.5	4	223	175	—	(S) 49	
Ca/S+NSR	@	9.40	6.32	4	45	125	1.4	(S) 49	
BL	@	9.30	6.44	3	215	1210	—	48.2	
Ca/S	@	9.425	6.28	4	210	145	—	(S) 49	
Ca/S+NSR	@	9.35	6.4	4	40	75	1.4	(S) 49	
BL	@	9.625	6.18	4	205	1340	—	48.2	
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Slurry setting $(49 \frac{ml}{min})(1.10 \frac{g}{ml})(.1598) = 8.61 \frac{g}{min}$ Ca(OH)$_2$ slurry.

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
tart	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2239	1974
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2200	1975

Innovative Furnace Data Log

Date: 3/29/91
Initials: EBC
Test: #N39

NH_3 Rotameter
Setting (BB height): 40
Fuel: natural GAS
Slurry: Ca(OH)$_2$ Tenn Lmt
% Excess Air (measured): —

SO_2 Rotameter
Setting (BB height): 35
Draft (inches of water): 0.9–1.0
Injection Port: 5th

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	9.90	6.38	12	352	1245	—	48	
Cal/S	@	10.25	6.10	15	342	475	—	(5) 49	9.60
Cal/S+NSR	@	10.475	6.00	30	140	300	1.4	(5) 49	
BL	@	10.925	5.60	6	320	1300	—	48	
Cal/S	@	10.875	5.60	9	318	600	—	(5) 49	
Cal/S+NSR	@	10.825	5.66	19	180	570	1.4	(5) 49	
BL	@	10.825	5.66	14	312	1250	—	48	
NSR	@	10.825	5.78	31	295	1265	1.4	48	
BL	@	10.725	5.70	22	310	1320	—	48	
NSR	@	10.75	5.72	37	298	1325	1.4	48	
BL	@	10.625	5.74	24	312	1340	—	48	
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Slurry setting $(49 \frac{ml}{min})(1.07 \frac{g}{ml})(.0960) = 5.03 \frac{g}{min}$ Ca(OH)$_2$ Slurry

					Temperature at Port (°F)		
	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
tart	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2190	1883
Finish	4.56 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2246	1923

Innovative Furnace Data Log

Date: 9/1/91
Initials: PBE
Test: #N40

NH$_3$ Rotameter Setting (BB height): 101
Fuel: Natural Gas
Slurry: Ca(OH)$_2$ slurry (Tanner Lot)
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 42
Draft (inches of water): 1.0
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	8.375	7.16	8	308	1500	—	48	9.7
Ca/S	@	8.50	7.12	8	315	475	—	(S) 50	
Ca/S+NSR	@	8.375	7.16	15	170	375	1.4	(S) 50	
BL	@	8.50	7.12	12	305	1530	—	48 [illegible]	
Ca/S	@	8.525	7.08	10	308	625	—	(S) 50	
Ca/S+NSR	@	8.60	7.10	20	170	500	1.4	(S) 50	
BL	@	8.625	7.00	12	305	1525	—	48	
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Slurry settings $(50 \frac{ml}{min})(1.07 \frac{g}{ml})(.0979) = 5.24 \frac{g}{min}$ Ca(OH)$_2$ Slurry

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
tart	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ –	Burned	2176	1881
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2121	1792

Innovative Furnace Data Log

Date: 4 / 22 /91 5 ebe
Initials ebe
Test: #N41

NH_3 Rotameter Setting (BB height): 107
Fuel: NATURAL gAS
Slurry: $Ca(OH)_2$
% Excess Air (measured): —

SO_2 Rotameter Setting (BB height): 40
Draft (inches of water): 1.0
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	8.875	6.70	19	312	1475	—	48	
Ca/S	@	8.75	6.80	17	325	240	—	(S) 49	14.11
Ca/S+NSR	@	8.625	6.90	32	257	100	1.4	(S) 49	
BL	@	8.85	6.86	21	305	1450	—	48	
Ca/S	@	8.65	6.90	36	300	450	—	(S) 49	
Ca/S+NSR	@	8.625	6.88	43	180	375	1.4	(S) 49	
BL	@	8.875	6.78	30	295	1450	—	48	
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Slurry Setting $(49\frac{ml}{min})(1.09\frac{g}{ml})(.1471) = 7.86\frac{g}{min}$ $Ca(OH)_2$ Slurry

					Temperature at Port (°F)		
	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
tart	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2157	1843
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Out	2080	1716

Date: 4,3,91

Initials CBC

Test: #N42

Innovative Furnace Data Log

NH$_3$ Rotameter Setting (BB height): 40

Fuel: natural Gas

Slurry: Ca(OH)$_2$ Tum LoT

% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 42

Draft (inches of water): 1.0

Injection Port: 4th upper

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	8.65	7.10	10	374	1505	—	48	OK
Ca/S	@	8.75	7.08	15	370	540	—	(S) 48	① 8.2
BL ~~Ca/S+NSR~~	@	8.75	7.10	20	370	1540	~~1.4~~ ebe	~~(S)~~ ebe 48	
als ~~BL~~ ebe	@	8.50	7.30	15	~~323~~ 315 ebe	775	—	(S) 48	①
Ca/S+NSR	@	8.85	7.10	40	30	590	1.4	(S) 48	①
BL	@	8.625	7.18	11	375	1625	—	48	
Ca/S	@	8.725	7.10	10	376	890	—	(S) 48	①
Ca/S+NSR	@	8.625	7.10	42	27	750	1.4	(S) 48	①
BL	@	8.70	7.10	9	370	1575	—	48	
Ca/S	@	8.75	7.10	9	372	1250	—	(S) 48.5	② 7.84
Ca/S+NSR	@	8.625	7.06	40	30	1175	1.4	(S) 48.5	②
BL	@	8.75	7.08	8	368	1600	—	48	
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(Slurry Setting #1) = (48 ml/min)(1.07 g/ml)(.0820) = 4.21 g/min Ca(OH)$_2$ Slurry

(Slurry Setting #2) = (48.5 ml/min)(1.03 g/ml)(.0384) = 1.92 g/min Ca(OH)$_2$ Slurry

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	Temperature at ~~Port~~ Section (°F) 2 ~~ese~~	 3 ~~ese~~	 4 upper
art	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	~~2155~~ Burned	~~1831~~ 2155	1831
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2153	1701

Innovative Furnace Data Log

Date: 4 / 4 / 91
Initials EBC
Test: #N43

NH$_3$ Rotameter
Setting (BB height): N/A
Fuel: natural gas
Slurry: Dry Inj Ca(OH)$_2$
% Excess Air (measured): —

SO$_2$ Rotameter
Setting (BB height): 33 - 34
Draft (inches of water): 1.0
Injection Port: 6th

	Solbant ~~Stage~~ Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	Feeder Setting ~~NO$_x$ OUT~~ ~~Feed Rate (ml/min)~~	Starting Feed Rate (~~ml~~ g/min)	Ending Feed Rate (ml/min)
BL	1.25 @ 30	8.85	6.98	17		1475	—	—	—
Cals	@	8.75	7.0	18		900	0.023	3	
BL	@	8.60	7.08	17		1430	—	—	—
Cals	@	8.50	7.10	17		925	0.023	3	
BL	@	8.575	7.10	17		1450	—	—	—
Cals	@	8.65	7.10	10		475	0.047	6	5.98
BL	@	8.725	7.02	7		1375	—	—	—
Cals	@	8.675	7.04	7		495	0.047	6	
BL	@	8.625	7.06	10		~~1375~~ 1390 ebc	—	—	—
Cals	@	8.575	7.06	9		310	0.070	9	
BL	@	8.625	7.10	9		1375	—	—	—
Cals	@	8.55	7.08	10		275	0.070	9	
BL	↓ @ ↓	8.55	7.08	10		1390	—	—	—
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Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
tart	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2188	1879
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2189	1872

Innovative Furnace Data Log

Date: 4 / 9 / 91
Initials CBC
Test: #N44

NH$_3$ Rotameter
Setting (BB height): N/A
Fuel: Natural GAS
Dry Inj ~~Slurry~~: CaCO$_3$ (as Recieved) Tenn Lot
% Excess Air (measured):

SO$_2$ Rotameter
Setting (BB height): ~~38~~ CBC 35
Draft (inches of water): 1.0
Injection Port: 4th upper

	Sorbent ~~Stage~~ Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	Feeder setting ~~NO$_x$ OUT Feed Rate (ml/min)~~	Starting Feed Rate g/(~~ml~~/min)	Ending Feed Rate g(~~ml~~/min)
BL	1.25 @ 30	11.00	5.82	21	75	1175	—	—	—
Cals	@	10.875	6.00	20	75	920	0.010	4.05	
BL	@	10.95	5.86	12	76	1160	—	—	—
Cals	@	10.875	6.04	5	75	910	0.010	4.05	
BL	@	10.875	5.90	6	75	1160	—	—	—
Cals	@	10.875	6.20	18	75	615	0.020	8.11	7.95
BL	@	10.825	5.96	3	74	1200	—	—	—
Cals	@	10.725	6.30	3	75	700	0.020	8.11	7.95
BL	@	10.70	6.00	3	75	1200	—	—	—
Cals	@	10.675	6.40	3	75	490	0.030	12.16	
BL	@	10.70	6.00	3	75	1170	—	—	—
Cals	@	10.75	6.46	6	75	475	0.030	12.16	
BL	@	10.65	6.04	7	75	1125	—	—	—
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Temperature at Section ~~Port~~ (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
tart	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2047	1731
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2056	1732

Innovative Furnace Data Log

Date: 4/9/91
Initials CBC
Test: #N45

NH$_3$ Rotameter
Setting (BB height): N/A
Fuel: Natural gas
Dry Inj ~~Slurry~~: CaCO$_3$ (As Received) Tenn Lmt
% Excess Air (measured): —

SO$_2$ Rotameter
Setting (BB height): 35
Draft (inches of water): 0.9-1.0
Injection Port: 5th

	Sorbent ~~Stage~~ Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	Feeder Setting ~~NO$_x$ OUT Feed Rate (ml/min)~~	Starting Feed Rate (~~ml~~ g/min)	Ending Feed Rate (~~ml~~ g/min)
BL	1.25 @ 30	10.625	6.00	16	76	1225	~~0.010~~ cby	—	—
Ca/S	@	10.55	6.18	18	76	925	0.010	4.05	—
BL	@	10.55	5.96	17	75	1225	~~0.010~~ cb	—	—
Ca/S	@	10.50	6.20	~~22~~ 18	75	895	0.010	4.05	—
BL	@	10.575	6.02	16	75	1225	~~0.020~~ cby	—	—
Ca/S	@	10.525	6.30	20	75	650	0.020	8.11	7.95
BL	@	10.60	6.00	19	75	1220	—	—	—
Ca/S	@	10.525	6.30	23	76	625	0.020	8.11	7.95
BL	@	10.60	6.04	21	76	1220	—	—	
Ca/S	@	10.50	6.42	26	76	450	0.030	12.16	
BL	@	10.60	6.02	23	75	1220	—	—	
Ca/S	@	10.50	6.40	29	76	430	0.030	12.16	
BL	@	10.575	6.06	30	75	1225	—	—	—
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Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2059	1735
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2083	1776

Innovative Furnace Data Log

Date: 4/12/91
Initials CBC
Test: #N46

NH$_3$ Rotameter
Setting (BB height): N/A
Fuel: natural Gas
Drying ~~Slurry~~: CaCO$_3$ (As Rec.)
% Excess Air (measured): —

SO$_2$ Rotameter
Setting (BB height):
Draft (inches of water): 1.0
Injection Port: 3 Rd middle

	Sorbent ~~Stage~~ Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	Feeder Setting ~~NO$_x$OUT Feed Rate (ml/min)~~	Starting Feed Rate g(~~ml~~/min)	Ending Feed Rate g(~~ml~~/min)
BL	1.25@ 30	11.00	5.88	14	~~Bo~~60	1300	—		
Cals	| @ |	10.875	6.08	15	62	1030	0.011	4.05	4.12
BL	@	10.875	5.94	15	63	1300	—		
Cals	@	10.825	6.12	16	64	1050	0.011	4.05	
BL	@	10.825	5.96	16	64	~~10~~1300	—		
Cals	@	10.70	6.24	17	64	800	0.022	8.11	8.61
BL	@	10.725	6.02	18	64	1300	—		
Cals	@	10.575	6.40	19	64	750	0.022	8.11	8.61
BL	@	11.025	5.82	20	63	1225	—		
Cals	@	10.90	6.44	22	65	520	0.033	12.16	13.00
BL	@	10.975	6.00	17	65	1300	—		
Cals	@	10.875	6.46	16	63	610	0.033	12.16	13.00
BL	V @ V	10.95	5.90	16	63	1260	—		
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Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
art	4.8 @ 45	1.0 @45	0.82@ 2	— @ —	Burned	1971	1710
Finish	4.8 @ 45	1.0 @45	0.82@ 2	— @ —	out	1966	1710

Innovative Furnace Data Log

Date: 4/15/91
Initials EDC
Test: #N47

NH$_3$ Rotameter
Setting (BB height): N/A
Fuel: natural gas
Dry Inj. ~~Slurry~~: CaCO$_3$ (as received) [illegible]
% Excess Air (measured): —

SO$_2$ Rotameter
Setting (BB height): 44
Draft (inches of water): 1.0
Injection Port: 4th Lower

	Sorbent ~~Stage~~ Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	Feeder setting ~~NO$_x$ OUT~~ ~~Feed Rate~~ ~~(ml/min)~~	Starting Feed Rate g(~~ml~~/min)	Ending Feed Rate g(~~ml~~/min)
BL	1.25 @ 30	8.875	7.04	19	81	1495	—	—	—
cals	@	8.85	7.20	19	83	1100	0.010	4.05	
BL	@	8.875	7.00	20	84	1440	—	—	—
cals	@	8.85	7.16	20	84	1100	0.010	4.05	
BL	@	8.925	7.04	20	84	1500	—	—	—
cals	@	8.85	7.38	20	84	875	0.020	8.11	
BL	@	8.90	7.06	20	84	1500	—	—	—
cals	@	8.85	7.38	21	85	900	0.020	8.11	
BL	@	8.975	7.00	21	84	1450	—	—	—
~~cals~~	~~@~~						~~0.030~~ [illegible]	~~12.16~~ [illegible]	
BL	@	8.50	7.20	21	86	1600	—	—	—
cals	@	8.45	7.66	25	85	625	0.030	12.16	11.85
BL	↓ @ ↓	8.575	7.20	24	84	1455	—	—	—
cals	@	8.50	7.68	25	84	575	0.030	12.16	11.85
BL	↓ @ ↓	8.6	7.20	25	89	1360	—	—	—
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Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
art	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2064	1825
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2104	1853

Innovative Furnace Data Log

Date: 4/16/91
Initials eBe
Test: #n46

NH$_3$ Rotameter
Setting (BB height): N/A
Fuel: Natural Gas
Dry Inj ~~Slurry~~: CaCO$_3$ (As Recieved) Tenn Lmt
% Excess Air (measured): —

SO$_2$ Rotameter
Setting (BB height): 44
Draft (inches of water): 1.0
Injection Port: 6th

	~~Stage~~ Sorbent Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	Feeder Setting ~~NO OUT~~ x ~~Feed Rate~~ ~~(ml/min)~~	Starting Feed Rate (~~ml~~ g/min)	Ending Feed Rate (~~ml~~ g/min)
BL	1.25 @ 30	8.75	7.20	8	80	1500	—		
Cals	@	8.80	7.34	10	82	1125	0,011	4.05	
BL	@	8.85	7.18	10	84	1455	—		
Cals	@	8.875	7.30	10	84	1125	0,011	4,05	
BL	@	8.925	7.10	10	84	1470	—		
Cals	@	8.875	7.40	14	85	850	0.022	8.11	8.2
BL	@	8.925 ~~8.875~~ ebe	7.10	12	85	1460	—		
ebe ~~Cals~~	@						~~0.022~~ ebe	~~8.11~~	
BL	@	8.875	7.10	12	85	1520	—		
Cals	@	8.85	7.40	17	85	900	~~0.022~~ ebe ~~0.033~~	~~12.16~~ 8.11	8.2
BL	@	8.90	7.12	15	85	1500	—		
Cals	@	8.75	7.56	16	85	675	0.033	12.16	
BL	@	8.875	7.14	20	85	1510	—		
Cals	@	8.75	7.56	20	86	650	0.033	12.16	
BL	@	8.85	7.12	20	86	1510	—		
	@								
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Temperature at ~~Port~~ section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
art	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned out	2085	1881
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —		2111	1889

Innovative Furnace Data Log

Date: 4 /16 / 91

Initials CBC

Test: #N49

NH$_3$ Rotameter Setting (BB height): N/A

Fuel: Natural gas

~~Slurry:~~ Dry Inj. CaCO$_3$ (as Received)

% Excess Air (measured): ——

SO$_2$ Rotameter Setting (BB height): 44

Draft (inches of water): 1.0 – 1.1

Injection Port: 7th

	~~Stage~~ Sorbent Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	Feeder Setting ~~NO OUT x Feed Rate~~ g(~~gal~~/min)	Starting Feed Rate g(~~gal~~/min)	Ending Feed Rate g(~~gal~~/min)
BL	1.25 @ 30	8.80	7.14	22	90	1520	—	—	—
Cals	@	8.625	7.30	25	89	1300	0.011	4.05	
BL	@	8.65	7.20	25	89	1555	—	—	
Cals	@	8.60	7.30	28	89	1275	0.011	4.05	
BL	@	8.70	7.20	26	88	1560	—	—	—
Cals	@	8.65	7.38	29	88	1090	0.022	8.11	8.2
BL	@	8.65	7.22	28	89	1570	—	—	—
cals	@	8.65	7.38	31	88	1090	0.022	8.11	8.2
BL	@	8.675	7.20	30	88	1575	—	—	—
Cals	@	8.65	7.40	37	88	940	0.033	12.16	
BL	@	8.70	7.20	34	87	1570	—	—	—
Cals	@	8.65	7.40	36	88	970	0.033	12.16	
BL	@	8.675	7.20	35	88	1550	—	—	—
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Temperature at ~~FSH~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
art	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2111	1889
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2121	1896

Innovative Furnace Data Log

Date: 4 / 17 / 91
Initials CBC
Test: #N50

NH_3 Rotameter Setting (BB height):	47	SO_2 Rotameter Setting (BB height):	49
Fuel:	NATURAL GAS	Draft (inches of water):	1.0
Slurry:	$CaCO_3$ (As Recieved)	Injection Port:	4th upper
% Excess Air (measured):	—		

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	8.80	7.10	7	375	1490	—	48	
Cals	@	8.75	7.28	5	370	945	—	(S) 49	①
Cals+NSR	@	8.625	7.36	20	145	875	1.4	(S) 49	①
BL	@	8.625	7.12	7	377	1485	—	48	
Cals	@	8.60	7.30	8	379	960 ~~941~~ CBC	—	(S) 49	①
Cals+NSR	@	8.55	7.34	24	190	940	1.4	(S) 49	①
BL	@	8.675	7.00	10	375	1525	—	48	
Cals	@	8.625	7.12	14	374	1150	—	(S) 50	②
Cals+NSR	@	8.575	7.20	32	198	1150	1.4	(S) 50	②
BL	@	8.625	7.02	16	376	1500	—	48	
Cals	@	8.65	7.10	17	373	1170	—	(S) 50	②
Cals+NSR	@	8.375	7.24	48	110	1075	1.4	(S) 50	②
BL	@	8.70	6.94	23	373	1495	—	~~BL~~ 48	
Cals	@	8.85 ~~8.875~~ CBC	6.96	24	370	1325	—	(S) 49.5	③
Cals+NSR	@	8.725	7.00	42	175	1300	1.4	(S) 49.5	③
BL	@	8.85	6.86	24	372	1475	—	48	
Cals	@	8.80	6.94	25	374	1275	~~1.4~~ CBC	(S) 49.5	③
Cals+NSR	@	8.60	7.08	48	166	1275	1.4 —	(S) 49.5	③
BL	↓ ↓	8.625	6.92	26	375	1585	—	48	

Temperature at Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
art	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2022	1768
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Out	2012	1663

Slurry setting #1) = (49 ml/min)(1.11 g/ml)(.1334) = 7.26 g/min $CaCO_3$ Slurry
(Slurry setting #2) = (50 ml/min)(1.07 g/ml)(.0907) = 4.85 g/min $CaCO_3$ Slurry
(Slurry setting #3) = (49.5 ml/min)(1.04 g/ml)(.0520) = 2.68 g/min $CaCO_3$ Slurry

Innovative Furnace Data Log

Date: 4 /18 /91
Initials ebe
Test: #N51

NH$_3$ Rotameter Setting (BB height): 58
Fuel: NATURAL GAS
Slurry: CaCO$_3$ (AS Recieved) Tennant
% Excess Air (measured): ——

SO$_2$ Rotameter Setting (BB height): 39
Draft (inches of water): 0.9 - 1.1
Injection Port: 4th Lower

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	9.50	6.60	7	315	1350	—	48	
Cal/S	@	9.475 ~~[illegible]~~	6.68	11	318	1100	—	(S) 49.5	①
Cal/S/NSR	@	9.45	6.72	56	49	1025	1.4	(S) 49.5	①
BL	@	9.20 ~~[illegible]~~	6.76	13	318	1325	—	48	
BL	@	9.50	6.58	17	311	1325	—	48	
Cal/S	@	9.60	6.60	17	314	1050	—	(S) 49.5	①
Cal/S/NSR	@	9.625	6.60	69	68	1050	1.4	(S) 49.5	①
BL	@	9.725	6.48	19	306	1325	—	48	
Cal/S	@	9.75	6.56	21	310	850	—	(S) 48.5	②
Cal/S/NSR	@	9.60	6.60	75	62	840	1.4	(S) 48.5	②
BL	@	9.70	6.42	25	306	1325	—	48	
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Slurry Setting #1) = (49.5 ml/min)(1.05 g/ml)(.0586) = 2.94 g/min CaCO$_3$ Slurry
Slurry Setting #2) = (48.5 ml/min)(1.08 g/ml)(.1144) = 5.99 g/min CaCO$_3$ Slurry

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	1991	1842
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2077	1812

Innovative Furnace Data Log

Date: 4/19/91
Initials cBY
Test: #n52

NH$_3$ Rotameter Setting (BB height): 58
Fuel: Natural gas
Slurry: CaCO$_3$ (as Recieved) Tam Lintl
% Excess Air (measured): ——

SO$_2$ Rotameter Setting (BB height): 46
Draft (inches of water): 0.9-1.1
Injection Port: 4th lower

	Stage Air (float height) @ PSI 9.25	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	~~8.85~~	6.66	0	327	1460	—	48	
Cals	@ 9.00	~~8.425~~	6.80	0	331	975	—	(S) 48.5	①
Cals+nSR	@	8.95	6.88	0	50	900	1.4	(S) 48.5	①
BL	@	9.15	6.66	0	323	1375	—	48	
Cals	@	9.225	6.76	0	327	930	—	(S) 48.5	①
Cals+nSR	@ 9.20	~~9.50~~	6.80	0	~~327~~ 55	900	1.4	(S) 48.5	①
BL	@	9.50	6.50	0	321	1400	—	48	
Cals	@	9.25	6.90	20	330	775	—	(S) 49	②
Cals+nSR	@	9.00	7.04	70	73	750	1.4	(S) 49	②
BL	@	9.075	6.82	20	331	1345	—	48	
Cals	@	8.95	7.10	25	332	615	—	(S) 49	②
Cals+nSR	@	8.875	7.14	90	45	620	1.4	(S) 49	②
BL	@	9.00	6.90	19	320	1325	—	48	
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(Slurry setting #1) = (48.5 ml/min)(1.13 g/ml)(.1181) = 6.47 g/min CaCO$_3$ Slurry
(Slurry setting #2) = (49 ml/min)(1.13 g/ml)(.1539) = 8.52 g/min CaCO$_3$ Slurry

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2027	1805
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2088	1830

Innovative Furnace Data Log

Date: 4/22/91
Initials: CBP
Test: #N53

NH_3 Rotameter Setting (BB height): 35
Fuel: NATURAL gAS
Slurry: $CaCO_3$ (AS REC.) Tomlinson
% Excess Air (measured): —

SO_2 Rotameter Setting (BB height): 50
Draft (inches of water): 1.0
Injection Port: 3rd Right

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	8.80	7.12	10	380	1410	—	48	
cals	@	8.85	~~7.40~~ 7.20	15 ~~9~~	373	~~750~~ 670	—	(5) 48	①
Ca/StmSR	@	8.75	7.40	36	233	625	1.4	(5) 48	①
BL	@	8.75	7.10	~~40~~ 32	380	~~1400~~ 1300	—	48	
Cals	@	8.625	7.44	25	379	750	—	(5) 48	~~②~~ ①
Ca/StmSR	@	8.50	7.54	40	170	600	1.4	(5) 48	~~②~~ ①
BL	@	8.825	7.06	25	380	1125	—	48	
BL	@	8.95	7.00	27	378	1375	—	48	
Cals	@	8.825	7.24	29	382	900	—	(5) 46	②
Ca/StmSR	@	8.625	7.30	40	290	900	1.4	(5) 46	②
BL	@	8.85	7.06	29	382	1200	—	48	
Cals	@	8.725	7.30	30	383	875	—	(5) 46	②
Ca/StmSR	@	8.50	7.50	42	250	850	1.4	(5) 46	②
BL	@	8.75	7.20	25	378	1250	-	48	
	@								
	@								
	@								
	@								

(Slurry Setting #1) = (48 ml/min) (1.14 g/ml) (.1801) = 9.86 g/min $CaCO_3$ Slurry
(Slurry Setting #2) = (46 ml/min) (1.09 g/ml) (.1078) = 5.41 g/min $CaCO_3$ Slurry

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
rt	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	1953	1802
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	1882	1675

Innovative Furnace Data Log

Date: 4/23/91
Initials GBC
Test: #N54

NH$_3$ Rotameter Setting (BB height): 33
SO$_2$ Rotameter Setting (BB height): 62
Fuel: natural GAS
Draft (inches of water): 1.0
Slurry: $CaCO_3$ (as Rec.) Tenn Lmt.
Injection Port: 3rd Right
% Excess Air (measured): —

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	9.125	6.90	20	365	1425	—	48	
Cal/S	@	9.10	7.12	21	366	1025	—	(S) 49	①
Cal/S+NSR	@	8.975	7.20	35	250	1000	1.4	(S) 49	①
BL	@	9.10	7.00	22	361	1405	—	48	
Cal/S	@	9.00	7.28	19	360	~~1025~~ 1050 GBC	—	(S) 49	①
Cal/S+NSR	@	8.875	7.30	25	250	1025	1.4	(S) 49	①
BL	@	9.00	7.10	15	360	1475	—	48	
Cal/S	@	9.00	7.20	15	363	1240	—	(S) 50	②
Cal/S+NSR	@	8.90	7.28	25	245	1200	1.4	(S) 50	②
BL	@	9.05	7.00	16	362	1445	—	48	
Cal/S	@	8.95	7.22	19	360	1250	—	(S) 50	②
Cal/S+NSR	@	8.875	7.26	25	260	1225	1.4	(S) 50	②
BL	@	9.025	7.00	18	363	1475	—	48	
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(Slurry setting #1) = $(49\ \frac{ml}{min})(1.09\ g/ml)(.1087) = 5.81\ g/min$ $CaCO_3$ Slurry

(Slurry setting #2) = $(50\ \frac{ml}{min})(1.05\ g/ml)(.0661) = 3.47\ g/min$ $CaCO_3$ Slurry

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
art	4.58 @ 45	1.0 @ 45	0.87 @ 2	— @ —	Burned	1989	1843
Finish	4.58 @ 45	1.0 @ 45	0.87 @ 2	— @ —	Out	1889	1693

Innovative Furnace Data Log

Date: 4/25/91
Initials eBC
Test: #N55

NH$_3$ Rotameter Setting (BB height): N/A
Fuel: natural GAS
~~Slurry~~: Dry Inj: Less than 10 μm CaCO$_3$
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 45
Draft (inches of water): 1.0
Injection Port: 5th

not.

	Sorbent ~~Stage~~ Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	Feeder Setting ~~NO$_x$ OUT~~ ~~Feed Rate~~ (~~ml/~~min)	Starting Feed Rate (g ~~ml~~/min)	Ending Feed Rate (g ~~ml~~/min)
BL	1.25 @ 30	9.05	7.10	16	75	1425	—		
Cals	@	8.975	7.28	18	78	845	0.031	4.05	
BL	@	8.85	7.32	11	78	1425	—		
Cals	@	8.875	7.48	10	80	930	0.031	4.05	2.90
BL	@	8.925	7.30	5	80	1340	—		
Cals	@	8.875	7.46	5	80	925	0.031 ~~0.063~~ EBC	~~8.11~~ 4.05 EBC	2.90
BL	@	8.925	7.30	3	80	1320	→		
Cals	@	8.85	7.58	5	80	580	0.063	8.11	6.28
BL	@	9.10	7.04	0	80	1525	→		
Cals	@	9.00	7.40	0	81	625	0.063 ~~0.095~~ EBC	EBC ~~12.16~~ 8.11	6.28
BL	@	9.10	7.10	0	81	1310	—		
Cals	@	8.95	7.54	2	81	340	0.095	12.16	9.44
BL	@	9.05	7.10	5 ~~2~~ [illegible]	81	1250	—		
Cals	@	8.90	7.50	3	82	390	0.095	12.16	9.44
BL	↓ @ ↓	8.95	7.12	3	83	1525	—		
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Temperature ~~at Port~~ @ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2080	1869
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2108	1875

Innovative Furnace Data Log

Date: 4/26/91
Initials ebc
Test: #N56

NH$_3$ Rotameter Setting (BB height): 33
Fuel: natural GAS
Slurry: Less Than 10 μm CaCO$_3$
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 51
Draft (inches of water): 1.0
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03@ ~~5~~70	8.90	7.10 ebc	11	330	1410	—	48	
Cals	@	8.625	7.40	13	330	690	—	(5) 50	
Cal/SNNSR	@	8.575	7.52	22	125	600	1.4	(5) 50	
B.L	@8.625	~~8.625~~ ebc	7.20 ~~7.44~~ ebc	17 ~~48~~ ebc	330 ~~335~~ ebc	1350 ~~750~~ ebc	—	48	
Cals	@	8.65	7.46	18	335	760 ~~640~~ ebc	—	(5) 50	
Cal/SNNSR	@	8.55	7.50	31	145	775	1.4	(5) 50	
BL	@	8.70 ~~8.575~~	~~7.70~~ ebc 7.20 ebc	20	335	1375	—	48	
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Slurry setting = (50 ml/min)(1.11 g/ml)(.1477) = 8.20 g/min CaCO$_3$ Slurry (Less than 10 μm) section

Temperature at ~~Port~~ (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2095	1853
Finish	4.58@ 45	1.0@ 45	0.82@ 2	— @ —	out	2073	1806

Innovative Furnace Data Log

Date: 4/26/91
Initials EBC
Test: #N57

NH$_3$ Rotameter Setting (BB height): 32
Fuel: natural gas
Slurry: Less Than 10μm CaCO$_3$
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 55
Draft (inches of water): 1.0
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	8.80	7.12	14	338	1525	—	48	
Ca/S	@	9.00	7.10	15	323	805	—	(S) 49	①
Ca/S+NSR	@	8.925	7.20	34	75	840	1.4	(S) 49	①
BL	@	9.25	6.80	15	320	1450	—	48	
Ca/S	@	8.975	7.12	20	330	990	—	(S) 49	①
Ca/S+NSR	@	8.85	7.28	33	85	1000	1.4	(S) 49	①
BL	@	8.95	7.04	20	325	1495	—	48	
Ca/S	@	9.125	7.00	20	325	1315	—	(S) 50	②
Ca/S+NSR	@	9.00	7.04	29	170	1280	1.4	(S) 50	②
BL	@	9.125	6.90	21	325	1550	—	48	
Ca/S	@	9.225	6.92	22	326	1355	—	(S) 50	②
Ca/S+NSR	@	9.15	6.98	30	220	1325	1.4	(S) 50	②
BL	↓ @ ↓	9.10	7.00	23	326	1515	—	48	
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Slurry setting #1 = (49 ml/min)(1.08 g/ml)(.0892) = 4.72 g/min CaCO$_3$ Slurry (>10μm)

Slurry setting #2 = (50 ml/min)(1.04 g/ml)(.0532) = 2.77 g/min CaCO$_3$ Slurry (>10μm)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	Temperature at ~~Port~~ Section (°F) 2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Buried	2068	1775
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2045	1708

Innovative Furnace Data Log

Date: 4 /29/ 91
Initials ebc
Test: #N58

NH$_3$ Rotameter
Setting (BB height): N/A
ebc Fuel: NATURAL GAS
DRY JET ~~Slurry:~~ 75μm > $CaCO_3$ > 25μm
% Excess Air (measured): —

SO$_2$ Rotameter
Setting (BB height): 52
Draft (inches of water): 1.0
Injection Port: 5th

ebc	Sorbent ~~Stage~~ Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	Feeder Setting ebc ~~NO$_x$ OUT Feed Rate (ml/min)~~	Starting Feed Rate ebc (g/min)	Ending Feed Rate ebc (g/min)
BL	1.25 @30	8.70	7.28	6	86	1445	—		
Cals	@	8.775	7.38	6	85	1070	0.013	4.05	
BL	@	8.50	7.40	7	87	1420	—		
Cals	@	8.75	7.30	7	87	1100	0.013	4.05	
BL	@	8.60	7.34	8	85	1400	—		
Cals	@	8.50	7.70	8	86	865	0.026	8.11	8.24
BL	@	8.60	7.34	3	87	1390	—		
Cals	@	8.50	7.70	0	88	825	0.026	8.11	8.24
BL	@	8.60	7.36	3	87	1465	—		
cals	@	8.725	7.66	0	87	675	0.039	12.16	
BL	@	8.75	7.22	0	88	1375	—		
ebc ~~Cals~~	@	8.60	7.76	0	89	640	0.039	12.16	
ebc ~~BL~~	@	8.825	7.14	0	88	1225	—		
	@								
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Temperature at Section ebc ~~Port~~ (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.8 @ 45	1.0@45	0.82@ 2	— @ —	Burned	2120	1917
Finish	4.8 @ 45	1.0 @45	0.82@ 2	— @ —	out	2133	1916

Innovative Furnace Data Log

Date: 5/2/91
Initials eBC
Test: #NS9

NH$_3$ Rotameter Setting (BB height): 33
Fuel: natural gas
Slurry: 75μm > CaCO$_3$ > 25μm
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 64
Draft (inches of water): 0.9-1.1
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	W03@ 70	8.95	7.02	14	334	1415	—	48	
Cal/S	@	8.875	7.24	14	334	970	—	(S) 50.5	①
Cal/S+NSR	@	8.75	7.32	23	184	950	1.4	(S) 50.5	①
BL	@	8.85	7.06	17	335	1275	—	48	
Cal/S	@	8.75	7.30	17	338	950	—	(S) 50.5	①
Cal/S+NSR	@	8.55	7.46	29	155	875	1.4	(S) 50.5	①
BL	@	8.775	7.10	18	339	1385	—	48	
Cal/S	@	9.125	6.98	18	335	1090	—	(S) 51.5	②
Cal/S+NSR	@	9.00	7.06	29	175	1070	1.4	(S) 51.5	②
BL	@	8.875	7.04	18	335	1300	—	48	
Cal/S	@	8.85	7.12	19	335	1160	—	(S) 51.5	②
Cal/S+NSR	@	8.725	7.20	31	160	1150	1.4	(S) 51.5	②
BL	@	8.825	7.06	18	337	1275	—	48	
Cal/S	@	8.85	7.08	18	340	1225	—	(S) 51.5	③
Cal/S+NSR	@	8.625	7.18	33	165	1225	1.4	(S) 51.5	③
BL	@	8.75	7.08	19	340	1325	—	48	
Cal/S	@	8.825	7.06	19	340	1240	—	(S) 51.5	③
Cal/S+NSR	@	8.70	7.18	38	135	1230	1.4	(S) 51.5	③
BL		8.725	7.06	20	343	1370	—		

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2009	1760
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2011	1655

(S.S #1) = (50.5 ml/min)(1.13 g/ml)(.1568) = 8.95 g/min CaCO$_3$ Slurry 75μm > CaCO$_3$ > 25μm
(S.S. #2) = (51.5 ml/min)(1.06 g/ml)(.0811) = 4.43 g/min CaCO$_3$ " " " "
(S.S. #3) = (51.5 ml/min)(1.04 g/ml)(.0476) = 2.55 g/min CaCO$_3$ " " " "

Innovative Furnace Data Log

Date: 5/3/91
Initials CBP
Test: #N60

NH$_3$ Rotameter Setting (BB height): 32
Fuel: Natural Gas
Slurry: CaO (Tenn Lmt)
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 67
Draft (inches of water): 1.0
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
~BL	103@70	9.10	7.02	18	330	1410	—	48	
Ca/S	@	8.875	7.00	18	335	600	—	(S) 52	①
Ca/S+NSR	@	8.825	7.06	27	110	600	1.4	(S) 52	①
BL	@	8.775	7.12	24	340	1400	—	48 *	
Ca/S	@	8.75	7.08	25	330	900	—	(S) 52	①
Ca/S+NSR	@	8.625	7.20	35	125	825	1.4	(S) 52	①
BL	@	8.675	7.22	30	331	1400	—	48	
Ca/S	@	8.575	7.22	30	330	920	—	(S) 52	②
Ca/S+NSR	@	8.55	7.26	39	125	920	1.4	(S) 52	②
BL	@	8.475	7.28	34	339	1440	—	48	
Ca/S	@	8.485	7.30	34	335	990	—	(S) 52	②
Ca/S+NSR	@	8.40	7.32	43	140	890	1.4	(S) 52	②
BL	@	8.825	7.06	39	326	1420	—	48	
Ca/S	@	8.80	7.10	38	328	1210	—	(S) 52.5	③
Ca/S+NSR	@	8.775	7.08	45	125	1200	1.4	(S) 52.5	③
BL	@	8.70	7.08	45	324	1500	—	48	
Ca/S	@	8.725	7.08	41	320	1350	—	(S) 52.5	③
Ca/S+NSR	@	8.85		43	225	1445	1.4	(S) 52.5	③
BL		8.75		43	325	1475	—	48	

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burner	2051	1835
Finish	4.56 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2022	1681

(Slurry setting #1) = (52 ml/min)(1.11 g/ml)(.1546) = 8.92 g/min CaO Slurry
(Slurry Setting #2) = (52 ml/min)(1.06 g/ml)(.0862) = 4.75 g/min CaO Slurry
(Slurry Setting #3) = (52 ml/min)(1.05 g/ml)(.0628) = 3.46 g/min CaO Slurry

Innovative Furnace Data Log

Date: 5/16/91
Initials: ebe
Test: #N61

NH$_3$ Rotameter Setting (BB height): 32
Fuel: natural gas
Slurry: Tenn Lmt (As Rec) CaCO$_3$
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 66
Draft (inches of water): 0.9-1.1
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03@ 70	8.975	7.10	15	335	1385	—	48	
Cal/s	@	8.975	7.30	16	335	940	—	(S) 49	①
Cal/s+NSR	@	8.90	7.34	28	183	925	1.4	(S) 49	①
BL	@	8.80	7.20	16	345	1475	—	48	
Cal/s	@	8.75	7.32	20	340	1275	—	(S) 49.5	②
Cal/s+NSR	@	8.525	7.42	37	195	1240	1.4	(S) 49.5	②
BL	@	8.90	7.08	25	335	1425	—	48	
Cal/s	@	8.85	7.20	30	338	1220	—	(S) 49.5	②
Cal/s+NSR	@	8.80	7.26	45	200	1220	1.4	(S) 49.5	②
BL	@	8.75	7.14	32	345	1525	—	48	
Cal/s	@	8.50 ~~8.98~~ ebe	7.38	33	~~336~~ 360 ebe	1425	—	(S) 50	③
Cal/s+NSR	@	8.50	7.36	56	140	~~1525~~ 1400 ebe	1.4	(S) 50	③
BL	@	8.625	7.24	35	355	1525	—	48	
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Temperature at ~~Port~~ Section (

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 up
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	1997	17
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	1996	165

(SS #1) = (49 ml/min)(1.11 g/ml)(.129) = 7.02 g/min CaCO$_3$ Slurry
(SS #2) = (49.5 ml/min)(1.07 g/ml)(.0823) = 4.36 g/min CaCO$_3$ Slurry
(SS #3) = (50 ml/min)(1.05 g/ml)(.0509) = 2.67 g/min CaCO$_3$ Slurry

Innovative Furnace Data Log

Date: 5/14/91
Initials QBC + W.H
Test: #N67

NH_3 Rotameter
Setting (BB height): 32
Fuel: NATURAL GAS
Slurry: 75 μm > $CaCO_3$ > 25 μm
% Excess Air (measured): —

SO_2 Rotameter
Setting (BB height): 50
Draft (inches of water): 0.9-1.0
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	7.50	7.90	22	370	1650	—	48	
Cals	@	7.575	8.10	21	370	935	—	(S) 48.5	①
Cals+NSR	@	7.50	8.18	35	300	875	1.4	(S) 48.5	①
BL	@	7.625	7.74	40	360	1575	—	48	
Cals	@	7.575	8.00	40	365	950	—	(S) 48.5	①
Cals+NSR	@	7.475	8.10	55	265	935	1.4	(S) 48.5	①
BL	@	7.575	7.76	43	360	1475	—	48	
Cals	@	7.55	7.88	44	357	1200	—	(S) 50	②
Cals+NSR	@	7.45	7.94	58	255	1175	1.4	(S) 50	②
BL	@	7.45	7.80	49	365	1505	—	48	
Cals	@	7.40	7.92	50	368	1185	—	(S) 50	②
Cals+NSR	@	7.325	7.98	63	260	1175	1.4	(S) 50	②
BL	@	7.40	7.82	50	359	1475	—	48	
	@								
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	@								
	@								

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.87 @ 2	— @ —	Burned	2052	1794
Finish	4.58 @ 45	1.0 @ 45	0.87 @ 2	— @ —	out	2039	1714

(SS#1) = (48.5 ml/min)(1.13 g/ml)(.1513) = 8.29 g/min $CaCO_3$ Slurry

(SS#2) = (50 ml/min)(1.06 g/ml)(.0857) = 4.54 g/min $CaCO_3$ Slurry

Innovative Furnace Data Log

Date: 5/15/98
Initials: EBC
Test: #N63

NH_3 Rotameter Setting (BB height): 32
Fuel: natural gas
Slurry: 75μm > $CaCO_3$ > 25μm
% Excess Air (measured): —

SO_2 Rotameter Setting (BB height): 52
Draft (inches of water): 0.9-1.0
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	8.00	7.60	30	355	1575	—	48	
Ca/S	@	8.075	7.64	36	352	1320	—	(S) 50	
Ca/S+NSR	@	7.975	7.70	53	168	[illegible] 1205	1.4	(S) 50	
BL	@	8.15	7.52	50	355	1595 [illegible] ~~1375~~	—	48	
Ca/S	@	8.075	7.62	55	350	1375	—	(S) 50	
Ca/S+NSR	@	8.00	7.66	80	200	1360	1.4	(S) 50	
BL	@	8.15	7.48	75	350	1600	—	48	
	@								
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	@								

Slurry setting = (50 ml/min)(1.05 g/ml)(.0529) = 2.78 g/min $CaCO_3$ Slurry

Temperature at ~~Port~~ section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2056	1776
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2043	1710

Innovative Furnace Data Log

Date: 5/16/91
Initials: EBT
Test: #N64

NH_3 Rotameter Setting (BB height): 32-33
Fuel: Natural Gas
Slurry: CaO (Tenn Lmt)
% Excess Air (measured): —

SO_2 Rotameter Setting (BB height): 47-48
Draft (inches of water): 0.9-1.0
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	8.625	7.28	56	330	1510	—	48	
Cals	@	8.525	7.24	60	330	400	—	(5) 50.5	①
Cals+WSR	@	8.40	7.34	80	135	125	1.4	(5) 50.5	①
BL	@	8.475	7.32	62	330	1525	—	48	
Cals	@	8.40	7.32	63	325	400	—	(5) 50.5	①
Cals+WSR	@	8.275	7.32	80	113	375	1.4	(5) 50.5	①
BL	@	8.40	7.34	65	325	1560	—	48	
Cals	@	8.375	7.32	69	328	715	—	(5) 51	②
Cals+WSR	@	8.25	7.42	90	80	500	1.4	(5) 51	②
BL	@	8.425	7.32	65	325	1585	—	48	
Cals	@	8.35	7.37	65	325	800	—	(5) 51	②
Cals+WSR	↓ @ ↓	8.25	7.36	80	100	625	1.4	(5) 51	②
BL	@	8.35	7.34	69	326	1610	—	48	
	@								
	@								
	@								
	@								
	@								

Temperature at ~~Port~~ section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2014	175
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2024	1678

(SS#1) = (50.5 $\frac{ml}{min}$)(1.09 $\frac{g}{ml}$)(.1382) = 7.61 $\frac{g}{min}$ CaO "Slurry"

(SS#2) = (51 $\frac{ml}{min}$)(1.05 $\frac{g}{ml}$)(.0911) = 4.88 $\frac{g}{min}$ CaO "Slurry"

Innovative Furnace Data Log

Date: 5/31/91
Initials ebc
Test: Q.C #1

NH$_3$ Rotameter
Setting (BB height): N/A
Fuel: NATURAL GAS
y Inj. ~~Slurry:~~ Ca(OH)$_2$
% Excess Air (measured): —

SO$_2$ Rotameter
Setting (BB height): 43
Draft (inches of water): 1.0
Injection Port: 5th

	Sorbent ~~Stage~~ Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	Feeder setting ~~NO$_x$OUT Feed Rate (ml/min)~~	Starting Feed Rate (~~ml~~ g/min)	Ending Feed Rate (~~ml~~ g/min)
BL	1.25 @ 30	7.70	7.70	19	98	1595	—		
cals	@	7.575	7.72	19	97	600	0.049	6 ~~sec~~	5.4
BL	@	7.60 ~~7.475~~	7.72	19	99	1550	—		
cals	@	7.525	7.74	19	99	660	0.049	6 ~~sec~~	5.4
BL	@	7.625	7.72	20	100	1660	—		
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Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	1.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2124	1818
Finish	4.8 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2132	1804

Innovative Furnace Data Log

Date: 6/3/91
Initials: EBE, AD, KRB, WH
Test: #N65

NH$_3$ Rotameter Setting (BB height): 32
Fuel: Natural Gas
Slurry: Ca(OH)$_2$
% Excess Air (measured):

SO$_2$ Rotameter Setting (BB height): 43
Draft (inches of water): 1.0
Injection Port: 4th Lance

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT A$^+$ Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	7.70	7.54	22	331	1585	—	48	
~~Cals~~	@						20 ~~Ga~~ —	~~39.5~~ 37.5	etc
Cal/stwsR	91-06-@3-01	7.475	7.50	83	50	550	7.0	39.5	
c ~~BL~~	@						—	~~48~~ 48	etc
Cal/stwsR	91-06-@3-02	7.50	7.60	73	45	562.50	7.0	39.5	
BL	91-06-@03-02	7.675	7.60	18	336	1450	—	* Flow	Rate
	@							was never	Reset
	@							For 48 ml	
	@								
	@								
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Slurry setting) = (39.5 ml/min)(1.09 g/ml)(.1444) = 6.22 g/min Ca(OH)$_2$ Slurry

Temperature at ~~Exit~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned		
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out		

107.59

Innovative Furnace Data Log

Date: 6/4/91
Initials ebe
Test: #N66

NH$_3$ Rotameter Setting (BB height): ~~43-4~~ 32 eBE
Fuel: Natural Gas
Slurry: Ca(OH)$_2$
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 43-44
Draft (inches of water): 1.0
Injection Port: 4th Lower

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	7.875	7.50	15	340	1570	—	48	
Ca/S	@	7.775	7.50	20	338	325	—	(S) 47	
Ca/S+NSR	@	7.675	7.56	80	45	250	1.4	(S) 47	
BL	@	7.75	7.60	15	340	1400	—	48	
Ca/S	@	7.725	7.60	22	340	515	—	(S) 47	
Ca/S+NSR	@	7.675	7.58	65	60	550	1.4	(S) 47	
BL	@	7.725	7.60	16	335	1430	—	48	
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Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 uppe
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2113	1776
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Out	2122	179

Slurry setting = $(47 \frac{ml}{min})(1.10 \frac{g}{ml})(.1455) = 7.52$ g/min Ca(OH)$_2$ Slurry

Innovative Furnace Data Log

Date: 6/5/91
Initials: EBE
Test: #N67

NH$_3$ Rotameter Setting (BB height): 34-35
Fuel: Natural Gas
Slurry: Ca(OH)$_2$
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 44-43'
Draft (inches of water): 1.0
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.05 @ 70	7.75	7.62	20	340	1625	—	48	91-06-05-01
cals	@	7.60	7.60	19	355	500	—	(S) 47.5	
Cals+NSR	@	7.475	7.70	45	135	125	1.4	(S) 47.5	91-06-05-02
~~Cals+NSR~~	@						~~1.4~~	~~48 (S)~~	~~91-06-05-03~~
BL	@						—	48	
	@								
	@								
	@								
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Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2072	1707
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ ↗	out	2091	1689

(Slurry setting) = $(47.5 \frac{ml}{min})(1.10 \, g/ml)(.1482) = 7.74$ g/min Ca(OH)$_2$ Slurry

Innovative Furnace Data Log

Date: 6/7/91
Initials CBC
Test: #N68 / #N69

	4u	3m
NH_3 Rotameter Setting (BB height):	35	35

Fuel: natural GAS
Slurry: ~~at ese~~ Ca(OH)$_2$
% Excess Air (measured): —

	4u	3m
SO_2 Rotameter Setting (BB height):	40	44

Draft (inches of water): 1.0
Injection Port: 4th upper | 3rd middle

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	8.675	7.08	13	325	1520	—	48	91-06-07-
Cals	@	8.75	6.98	12	325	350	—	(S) 41.5	①
Cals +NSR	@ 8.525	~~[illegible]~~	7.12	20	262	275	6.5	(S) 41.5	91-06-07-
	@						—		
	@								
	@	TEST #N69							
	@								
BL	1.03 @ 70	8.625	7.10	14	355	1550	—	47.5	91-06-07-
Cals	@	8.625	7.10	12	360	475	—	(S) 41	②
Cals+NSR	@	8.50	7.04	18	390	400	6.5	(S) 41	91-06-07-
	@						—	—	
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	@								

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2047	1649
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2051	1600

Slurry setting #1) $= (41.5 \frac{ml}{min})(1.11 \frac{g}{ml})(.1481) = 6.82 \frac{g}{min}$ Ca(OH)$_2$

Slurry setting #2) $= (41.0 \frac{ml}{min})(1.08 \frac{g}{ml})(.1418) = 6.28 \frac{g}{min}$ Ca(OH)$_2$

Innovative Furnace Data Log

Date: 6/10/91
Initials: eBT
Test: #N70

NH$_3$ Rotameter Setting (BB height): 38
Fuel: Natural GAS
Slurry: Ca(OH)2
% Excess Air (measured):

SO$_2$ Rotameter Setting (BB height): 45
Draft (inches of water): 1.0
Injection Port: 5th.

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	@	7.825	7.50	20	357	1575	—	48	91-06-10-01
	@								
Cals	@	7.825	7.40	27	355	325	—	(S) 42.5	
	@								
Cals+nse	@	7.475	7.60	30	80	725	6.5	(S) 42.5	91-06-10-02
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Section
Temperature at [redacted]R (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2170	1882
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Out	2171	1885

Slurry setting = $(42.5 \frac{ml}{min})(1.10 \frac{g}{ml})(.1439) = 6.73 \frac{g}{min}$ Ca(OH)$_2$

Innovative Furnace Data Log

Date 6 / 11 / 91
Initials CBE
Test: #N71 / #N72 5th | 4L

NH$_3$ Rotameter Setting (BB height): 37 | 37
Fuel: natural GAS
Slurry: N/A
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 5th | 4L — 52 | 49
Draft (inches of water): 1.0
Injection Port: 5th

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	7.875	7.42	14	357	1565	—	48	91-06-11-01
	@								
NSR	1.03 @ 70	7.725	7.50	110	~~110~~ 120 CBE	1675	5.5	44	91-06-11-02
	@								
	@								
BL	1.03 @ 70	7.90	7.40	14	345	1615	—	47.9	91-06-11-0
	@								
NSR	1.03 @ 70	7.85	7.46	80	90	1625	5.5	44	91-06-11-04
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Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2108	1772
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2134	1818

Innovative Furnace Data Log

Date: 6/12/91
Initials: ebe
Test: #N 73 + #N74

NH_3 Rotameter Setting (BB height): 4u 35 | 3m 35
Fuel: Natural Gas
Slurry: N/A
% Excess Air (measured): –

SO_2 Rotameter Setting (BB height): 4u 52 | 3m 45
Draft (inches of water): 1.0
Injection Port: 4u / 3m

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	7.65	7.62	16	373	1650	—	48	91-06-12-01
	@								
NSR	1.03 @ 70	7.50	7.62	31	293	1720	5.5	44	91-06-12-02
	@								
	@								
	@								
BL	1.03 @ 70	7.625	7.52	21	388	1525	—	48	91-06-12-0
	@								
NSR	1.03 @ 70	7.45	7.60	33	388	1570	5.2	44	91-06-12-
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Temperature at Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	– @ –	Burned	2068	1683
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	– @ –	out	1965	1571

Innovative Furnace Data Log

14 ebe

Date: 6/~~15~~/91
Initials ebe
Test: #n75

NH_3 Rotameter
Setting (BB height): n/A
Fuel: Pitts #8 (26.3 g/min)
Slurry: $Ca(OH)_2$
% Excess Air (measured): —

SO_2 Rotameter
Setting (BB height): N/A
Draft (inches of water): 1.0
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT A Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	10.45	9.20	150	385	800	—	48	91-06-~~15~~ 14 -0
	@								
Cals	1.03 @ 70	10.325	9.20	168	385	275	—	(S) 44.5	
	@								
als+NSR	1.03 @ 70	~~10.375~~ ebe	9.20	600	160	250	4.3	(S) 44.5	91-06-~~15~~ 14 -0
	@	10.125							
	@								
	@						NOxOUT A		
	@								
Cals+NSR	1.03 @ 70	10.25	9.20	650	~~8~~ 250	250	1.4	(S) 44.5	91-06-14-0
	@								
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	@								
	@								

Slurry Setting = (44.5 ml/min)(1.08 g/ml)(.1487) = 7.15 g/min $Ca(OH)_2$ Slurry

Temperature at ~~Port~~ (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	0.95 @ 45	0.8 @ 45	— @ —	1.59 @ 30	Burner	1891	1445
Finish	0.95 @ 45	0.8 @ 45	— @ —	1.59 @ 30	out	1917	1402

Innovative Furnace Data Log

Date: 6/17/91
Initials: ebc
Test: #N76

NH_3 Rotameter Setting (BB height): N/A
Fuel: Pitts #8 Coal (26.7 g/min)
Slurry: $Ca(OH)_2$
% Excess Air (measured): ——

SO_2 Rotameter Setting (BB height): N/A
Draft (inches of water): 1.0
Injection Port: 4th Lower

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT A Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	10.375	9.20	60	365	750	—	48	91-06-17-01
	@								
CaIS	1.03 @ 70	10.525	8.96	100	380	75	—	(S) 44	
	@								91-06-17-
CaIS 4nSR	1.03 @ 70	10.25	8.70	320	285	100	1.4	(S) 44	~~91-06-17~~ebc
	@								
	@						Notout A ~~ms~~		
	@								
4nSR	1.03 @	10.625	8.60	~~16~~ ebc	280	100	4.3	(S) 44	91-06-17-0
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Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	0.95 @ 45	08 @ 45	— @ —	1.60 @ 30	Burned	1998	1694
Finish	0.95 @ 45	08 @ 45	— @ —	1.60 @ 30	out	2001	1676

(Slurry Setting) = $(44 \frac{ml}{min})(1.07 \frac{g}{ml})(.1121) = 5.28 \frac{g}{min}$ $Ca(OH)_2$ Slurry

Innovative Furnace Data Log

Date: 6/18/91
Initials eDC
Test: #N77, #N78, #N79

NH$_3$ Rotameter Setting (BB height):

5	4L	4U
30	30	30

Fuel: WMWM GAS
Slurry: N/A
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height):

5	4L	4U
51	45	45

Draft (inches of water): 1.0
Injection Port: 5th, 4th Lower, 4th upper

(176ml NOxOUT A) (1824ml DI H$_2$O)

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT A Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	8.725	6.90	0	380	1475	—	48	91-06-18-01
	@								
NSR	1.03 @ 70	8.825	6.90	30	250	1535	10	38.5	91-06-18-02
	@								
	@								
	@								
BL	1.03 @ 70	8.75	6.84	15	383	1500	—	48.5	91-06-18-03
	@								
NSR	1.03 @ 70	8.75	6.90	55	180	1525	10	38.5	91-06-18-04
	@								
	@								
BL	1.03 @ 70	8.725	6.92	16	388	1500	—	48	91-06-18-0
	@								
NSR	1.03 @ 70	9.125	6.76	45	180	1500	10	39	91-06-18-0
	@								
	@								
	@								
	@								

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2039	1671
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2086	1710

Innovative Furnace Data Log

Date: 6 / 19 / 91
Initials CBE
Test: #N80, #N81, #N82

	3m	3R	2R
NH3 Rotameter Setting (BB height):	32	29	23
SO2 Rotameter Setting (BB height):	47	43	38

Fuel: Natural Gas
Slurry: N/A
% Excess Air (measured): —
Draft (inches of water): 0.9-1.0-1.1
Injection Port: 3m, 3R, 2R

(176ml noxout A)
(1824ml D.I. H_2O)

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT A Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	8.45	6.80	15	389	1525	—	48	~~91-19-0~~ CBE
	@								91-06-19-01
NSR	1.03 @ 70	9.00	6.78	44	98	1575	10	38	
	@								
	@								
BL	1.03 @ 70	8.325	7.20	20	395	1550	—	48	91-06-19-0
	@								
NSR	1.03 @ 70	8.95	6.86	46	100	1525	10	~~38~~ 38 CBE	91-06-19-
	@								
	@								
BL	1.03 @ 70	8.95	6.80	18	370	1445	—	48.5	91-06-19-0
	@								
NSR	1.03 @ 70	8.875	6.86	28	260	1625	10	39	91-06-19-06
	@								
	@								
	@								
	@								
	@								

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	1913	1531
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	1794	1430

Innovative Furnace Data Log

Date: 9/12/91
Initials: CBC + WH
Test: CN1

NH_3 Rotameter Setting (BB height):	15.5	SO_2 Rotameter Setting (BB height):	27
Fuel:	Natural Gas	Draft (inches of water):	1.0
Slurry:	H_2O	Injection Port:	5th
% Excess Air (measured):	—		

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	H_2O Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)	SA #
BL	1.03 @ 70	11.462	5.08	12.78	268.65	1154.1	—	48		9/-
NSR	@	11.521	5.069	23.53	198.25	1174.2	Ⓐ 8	40		
BL	@	11.598	5.003	12.41	267.42	1189.6	—	48		
NSR	@	11.336	5.166	24.09	201.70	1248.3	Ⓐ 8	40		9/-
BL	@	11.151	5.251	12.04	266.92	1307.0	—	48		
NSR	@	11.012	5.325	15.38	177.12	1366.4	A^+ 8	40		
BL	@	11.527	5.051	12.78	246.12	1333.2	—	48		
NSR	@	11.706	4.917	14.08	165.61	1370.3	A^+ 8	40		9/-
BL	@	10.480	5.566	14.77	248.39	1419.7	—	48		
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	@		Room		Air	Blank				9/
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	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
					Temperature at Port (°F)		
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2070	1644
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2113	1686

*. NOxOUT A → 921.3 ml D.I H_2O; 78.7 ml NOxOUT A

NOxOUT A^+ → 846.4 ml D.I H_2O; 153.6 ml NOxOUT A^+

Innovative Furnace Data Log

Date: 9/13/91 — Friday the 13th
Initials EBE + WH
Test: — CN2

NH$_3$ Rotameter Setting (BB height): 15
Fuel: natural GAS
Slurry: DI H2O
% Excess Air (measured): ——

SO$_2$ Rotameter Setting (BB height): 25.5
Draft (inches of water): 1.0
Injection Port: 4th Lower

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)	Sa #
BL	1.03 @ 70	11.163	5.258	12.78	273.59	1158.0	——	48		
NSR	@	11.231	5.277	29.64	168.97	1164.9	Ⓐ 8	40		
BL	@	11.209	5.206	10.93	267.42	1185.0	——	48		
NSR	@	11.222	5.225	31.68	172.06	1206.6	Ⓐ 8	40		91-0
BL	@	10.84	5.366	11.12	261.24	1266.0	——	48		
NSR	@	10.799	5.455	14.45	100.17	1273.0	(A+) 8	40		
BL	@	10.755	5.399	11.67	260.13	1267.6	——	48		
NSR	@	10.842	5.425	15.01	105.61	1277.6	(A+) 8	40		91-0
BL	✓ @ ✓	10.684	5.506	12.60	258.77	1297.7	——	48		
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					Temperature at Port (°F)		
	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2055	1650
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2093	1668

* noxout A Solution The Same AS 9/12/91

noxout A+ Solution The Same AS 9/12/91

Innovative Furnace Data Log

Date: 9/13/91
Initials: YBC with CN3
Test: Ammonia + N2O Sampling

NH3 Rotameter Setting (BB height): 16.5
Fuel: natural GAS
Slurry: DI H2O
% Excess Air (measured): —

SO2 Rotameter Setting (BB height): 24
Draft (inches of water): 1.0
Injection Port: 4th upper

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	H_2O Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	10.956	5.343	12.6	296.44	1222.8	—	48	
NSR	@	10.941	5.347	48.73	77.45	1224.4	Ⓐ 8	40	
BL	@	10.971	5.355	12.78	296.20	1215.9	—	48	
NSR	@	10.925 ~~10.925~~	5.343	50.58	76.83	1218.2	Ⓐ 8	40	
BL	@	10.805	5.388	12.97	290.27	1218.2	—	48	
NSR	@	10.851	5.358	20.94	59.54	1228.2	(A+) 8	40	
BL	@	10.941	5.329	12.78	295.33	1222.1	—	48	
NSR	@	10.882	5.325	20.57	59.54	1229.8	(A+) 8	40	
BL	@	10.792	5.366	12.97	292.24	1205.1	—	48	
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					Temperature at ~~Port~~ Section (°F)		
	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2096	1667
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2070	1623

* NoxOut A ⇒ Same AS yesterday's Solution

* NoxOut A+ ⇒ Same AS yesterday's Solution

Innovative Furnace Data Log

Date: 9/13/-91
Initials CBC + WFH
Test: CN4

NH$_3$ Rotameter Setting (BB height): 16
Fuel: NATURAL GAS
Slurry: —
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 25.5
Draft (inches of water): 1.0
Injection Port: 3M

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	DI H$_2$O Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03 @ 70	10.684	5.466	15.19	304.22	1211.2		48.	
NSR	@	10.601	5.510	66.51	51.01	1227.5	8.0	40	A
BL	@	10.530	5.547	14.27	304.84	1222.8		48	
NSR	@	10.505	5.599	52.06	56.82	1243.7	8.0	40	A
BL	@	10.212	5.744	15.93	309.78	1271.5		48	
NSR	@	10.922	5.292	38.35	52.87	1230.5	8.0	40	A+
BL	@	10.885	5.336	14.82	288.04	1221.3		48	
NSR	@	10.468	5.566	47.99	55.95	1225.1	8.0	40	A+
BL	@	10.885	5.336	14.82	288.04	1221.3		48	
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LOST LAST BL DUE TO ERROR IN MOVING PROBE

91-0[illegible]
91-0[illegible]

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2031	1599
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	OUT	2003	1576

Innovative Furnace Data Log

Date: 9/13/91
Initials BC+WH CN5
Test: Ammonia and N_2O sampling

NH_3 Rotameter Setting (BB height): 16.5
Fuel: natural GAS
Slurry: DI H_2O
% Excess Air (measured): ——

SO_2 Rotameter Setting (BB height): 25
Draft (inches of water): 1.0
Injection Port: 3R

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)	
BL	1.03 @ 70	11.129	5.151	14.82	273.84	1189.6	——	48		
NSR	@	11.299	5.091	50.77	57.93	1209.7	Ⓐ 8	40		
BL	@	11.410	5.080	17.05	271.99	1203.5	——	48		
NSR	@	11.928	5.003	53.36	WB 58.56	1225.9	Ⓐ 8	40		91-01
BL	@	11.666	4.917	15.75	272.36	1220.5	——	48		
NSR	@	11.552	4.910	27.98	104.87	1236.7	Ⓐ 8	40		
BL	@	11.648	4.928	16.49	276.56	1235.2	——	48		
NSR	@	11.663	4.917	26.50	105.48	1243.7	Ⓐ 8	40		91-0
BL	↓ @ ↓	10.683	5.532	16.68	284.34	1246.8	——	48		
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Temperature at Port (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	1997	1544
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Out	1971	1434

Innovative Furnace Data Log

Date: 9/16/91
Initials CBC ruf CNG
Test: Ammonia and N_2O Sampling

NH_3 Rotameter Setting (BB height): 16
Fuel: natural GAS
Slurry: DI H_2O
% Excess Air (measured): —

SO_2 Rotameter Setting (BB height): 27.5
Draft (inches of water): 1.0
Injection Port: 2R

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)	S#
BL	1.03 @ 70	11.496	5.043	16.86	285.85	1171.1	—	48		91-0
NSR	@	11.500	5.040	21.12	196.89	1205.1	Ⓐ 8	40		
BL	@	11.99	4.754	18.53	276.8	1395.8	—	48		
NSR	@	12.139	4.643	23.90	180.46	1487.6	Ⓐ 8	40		91-
BL	@	12.463	4.480	17.05	277.67	1664.4	—	48		
NSR	@	11.796	4.891	21.31	335.22	1710.7	(A+) 8	40		
BL	@	11.852	4.723	17.97	285.99	1750.1	—	48		
NSR	@	11.561	4.969	19.45	337.20	1795.6	(A+) 8	40		91-
BL	@	11.811	4.791	18.34	286.07	1930	—	48		
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Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	1961	1894
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	1844	1578

Innovative Furnace Data Log

SO$_2$ Levels Are Due to Bad Anacon Analyzer

Date: 9/16/91
Initials: EBC + WH CNT
Test: Ammonia And N$_2$O Sampling

NH_3 Rotameter Setting (BB height): 15
Fuel: Natural Gas
Slurry: AI H$_2$O
% Excess Air (measured): —

SO_2 Rotameter Setting (BB height): 11
Draft (inches of water): 1.0
Injection Port: 3 m

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)	
BL	1.03 @ 70	11.666	4.899	18.53	258.65	1697.6	—	—		91-0
NSR	@	11.642	4.910	59.47	57.93	1875.9	A 8	40		
BL	@	11.657	4.877	18.71	258.40	1883.6	—	48		
NSR	@	11.700	4.891	66.57	61.39	1916.8	A 8	40		91-09
BL	@	11.549	4.928	19.64	265.44	1968.6	—	48		
NSR	@	11.583	4.832	38.72	81.65	1992.5	A+ 8	40		
BL	@	11.620	4.899	19.64	268.28	2012.6	—	48		
NSR	@	11.188	5.064	42.80	87.20	2044.2	A+ 5	40		91-0
BL	@	10.508	5.503	20.20	265.32	2120.6	—	48		
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Temperature at Port (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	82 @ 2	— @ —	Burned	1922	1523
Finish	@	@	@	— @ —	out		

Innovative Furnace Data Log

Date: 9/17/91
Initials ebe+wff CNB
Test: Ammonia + N_2O Sampling

NH_3 Rotameter
Setting (BB height): 14
Fuel: natural gas
Slurry: DI H_2O
% Excess Air (measured):

SO_2 Rotameter
Setting (BB height): N/A
Draft (inches of water): 1.0
Injection Port: 3m

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)	Samp #
BL	103 @ 70	11.453	5.088	17.05	274.46	N/A	—	48		
NSR≈0.5	@	11.425	5.099	22.42	152.17		(A) 8	40		
BL	@	12.049	4.695	15.93	239.13		—	48		
NSR≈0.5	@	12.071	4.706	24.27	128.46		(A) 8	40		91-09
BL	@	12.018	4.765	17.79	237.52		—	48		
NSR≈0.5	@ 11.963	~~12.~~ ebe	4.725	17.05	166.50		(A+) 8	40		
BL	@	11.957	4.773	15.56	236.17		—	48		
NSR≈0.5	@	11.957	4.758	19.83	162.43		(A+) 8	40		91-0
BL	@	11.904	4.732	17.97	236.66		—	48		
NSR≈1.5	@	11.852	4.765	51.14	29.64		(A) 8	40		
BL	@	11.898	4.802	15.93	235.67		—	48		
NSR≈1.5	@	11.879	4.806	54.84	32.24		(A) 8	40		91-09
BL	@	11.901	4.747	16.68	232.58		—	48		
NSR≈1.5	@	11.932	4.754	33.54	29.64		(A+) 8	40		
BL	@	11.932	4.713	17.05	230.98		—	48		
NSR≈1.5	@	11.975	4.713	36.69	31.50		(A+) 8	40		91-09
BL	@	11.997	4.662	16.89	229.99		—	48		
	@									

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2129	1789
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	2006	1546

Innovative Furnace Data Log

Date: 9/17/91
Initials EBC+WH CN89
Test: Ammonia and N_2O Sampling

NH_3 Rotameter
Setting (BB height): 14
Fuel: Natural Gas
Slurry: D.I. H_2O
% Excess Air (measured): ——

SO_2 Rotameter
Setting (BB height): N/A
Draft (inches of water): 1.0
Injection Port: 3rd

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)	Sam #
BL	1.03@70	11.997	4.662	16.59	229.99	N/A	—	48		
NSR≈2.0	@	11.978	4.721	51.69	36.56		(A*) 8	40		
BL	@	12.071	4.665	17.97	227.27		—	48		
NSR≈2.0	@	11.978	4.691	62.07	38.66		(A) 8	40		91-09
BL	@	11.941	4.706	17.23	225.67		—	48		
NSR≈2.0	@	11.870	4.773	49.47	29.77		(A+) 8	40		
BL	@	11.923	4.691	17.97	226.41		—	48		
NSR≈2.0	@	11.858	4.721	43.17	31.00		(A+) 8	40		91-09
BL	@	11.898	4.699	17.97	223.81		—	48		
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Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58@ 45	1.0 @45	0.52@ ~~45~~ 2	— @ —	Burned	4006	1546
Finish	4.58@ 45	1.0 @ 45	0.82@ ~~4~~ 2	— @ —	out	1979	1463

Innovative Furnace Data Log

Date: 9 21, 91
Initials: EBC + HH CNIO
Test: Ammonia And N_2O Sampling

NH_3 Rotameter Setting (BB height):	3m / 3R	14.5 / 14.5
SO_2 Rotameter Setting (BB height):	3m / 3R	25 / 22

Fuel: Natural Gas
Draft (inches of water): 1.0
Slurry: D.I H_2O
Injection Port: 3m / 3R
% Excess Air (measured): —

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	Ⓐ NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)	Sa #
BL	1.03 @ 70	11.759	4.999	12.23	263.71	1117.8	—	48		
M NSR	↓ @ ↓	11.997	4.869	25.94	43.73	1143.3	8	40		
BL	@	12.058	4.825	12.78	262.98	1133.3	—	48		
NSR	@	12.089	4.814	29.27	42.61	1159.5	8	40		9/-0
BL	↓ @ ↓	11.493	5.162	13.71	264.95	1177.3	—	48		
	@									
	@									
	@									
BL	1.03 @ 70	12.620	4.517	13.16	249.38	1007.4	—	48		
E NSR	↓ @ ↓	12.673	4.447	28.16	50.27	1024.4	8	40		
BL	@	12.735	4.443	12.04	245.92	1029.1	—	48		
NSR	@	12.701	4.476	29.27	51.51	1038.3	8	40		91-0
BL	↓ @ ↓	10.752	5.662	12.60	248.64	1049.1	—	48		
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	@									

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58@45	1.0@45	0.82 @ 2	— @ —	Burned	2043	1663
Finish	4.58@ 45	1.0 @45	0.83@ 2	— @ —	out	1974	1544

Innovative Furnace Data Log

Date: 11 /26 91
Initials: CBE
Test: CN11

NH$_3$ Rotameter Setting (BB height): 20
Fuel: NATURAL GAS
Slurry: Ten wt Ca(OH)$_2$
% Excess Air (measured): —

SO$_2$ Rotameter Setting (BB height): 47
Draft (inches of water): 1.0
Injection Port: 3m

	Stage Air (float height) @ PSI	O$_2$ (%)	CO$_2$ (%)	CO (ppm)	NO (ppm)	SO$_2$ (ppm)	NO$_x$OUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)	SA Te #
BL	1.03 @ 70	10.104	5.973	11.12	326.33	1325.5	(H$_2$O) 5	49		91-1-
Ca/S	@	9.715	6.051	93.90	333.37	121.20	(H$_2$O) 5	48 (S)	8.29 g/min	
Ca/S+NSR	@	9.631	6.114	47.00	109.57	19.30	5 (A)	48 (S)		91-11
BL end	@	9.758	6.114	10.38	320.78	128.2	5	48		
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					Temperature at Port (°F)		
	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2030	1604
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	1986	1459

Innovative Furnace Data Log

Date: 11 /27/91
Initials CBC+WFH
Test: CN12

NH_3 Rotameter
Setting (BB height): 18
Fuel: N.G.
Slurry: Ca(OH)2
% Excess Air (measured):

SO_2 Rotameter
Setting (BB height): 54
Draft (inches of water): 1.0
Injection Port: 3M

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)
BL	1.03@70	9.946	6.06	7.8	330	1366	(H_2O) 5	· 48	
Ca/S	@	9.940	6.003	12.60	326.33	196.08	(H_2O) 5	(S) 48	
Ca/S+NSR	@	9.863	6.022	20.57	118.08	121.97	(A+) 5	(S) 48	8.043/min 91-4
BL	@	9.863	6.085	9.63	309.91	1399.6	(H_2O) 5	48	
Ca/S	@						(H_2O) 5	(S)	
Ca/S+NSR	@		Water in		NOx		(A) 5	(S)	
BL	@		Analyzer				(H_2O) 5	48	
	@								
	@								
	@								
	@								
	@								
	@								
	@								
	@								
	@								
	@								

Temperature at Port (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58@ 45	1.0@ 45	0.82@ 2	— @ —	—	2022	1615
Finish	4.58 @ 45	1.0 @ 45	0.82@ 2	— @ —	—		

Innovative Furnace Data Log

Date: 12/2/91
Initials eBe CN13
Test: N_2O + Ammonia Testing

NH$_3$ Rotameter
Setting (BB height): 15
Fuel: NAtural GAS
Slurry: Tenn Luttrel $Ca(OH)_2$
% Excess Air (measured): —

SO$_2$ Rotameter
Setting (BB height): 48
Draft (inches of water): 1.0
Injection Port: 3m

	Stage Air (float height) @ PSI	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	SO_2 (ppm)	NO_xOUT Feed Rate (ml/min)	Starting Feed Rate (ml/min)	Ending Feed Rate (ml/min)	
BL	1.03 @ 70	9.792	6.148	10.19	317.07	1346.3	(W) 5	(W) 48		
Cal S	@	9.529	6.240	11.86	321.39	485.39	(W) 5	(S) 47	5.50	
Cal S + NSR	@	9.477	6.218	26.12	101.66	353.57	(A) 5	(S) 47	5.50	91-1
BL	@	9.810	6.099	9.63	307.81	1381.1	(W) 5	(W) 48		
Cal S	@	9.638	6.114	12.41	308.05	573.59	(W) 5	(S) 47	5.50	
Cal S + NSR	@	9.533	6.129	22.79	75.96	535.76	(A+) 5	(S) 47	6.50	91-1
BL	@	9.749	6.044	12.04	295.95	1447.5	(W) 5	(W) 48		
BL	@	9.739	6.044	10.38	292.24	1357.9	(W) 5	(W) 48		
Cal S	@	9.659	6.114	12.60	294.34	948.77	(W) 5	(S) 48	2.94	
Cal S + NSR	@	9.585	6.088	37.98	120.92	945.68	(A) 5	(S) 48	2.94	91-1
BL	@	9.468	6.185	13.34	300.02	1359.5	(W) 5	(W) 48		
Cal S	@	9.418	6.136	13.34	300.64	1043.7	(W) 5	(S) 48	2.94	
Cal S + NSR	@	9.369	6.196	23.72	70.90	988.91	(A+) 5	(S) 48	2.94	91-12
BL	@	9.319	6.236	11.12	293.97	1307.0	(W) 5	(W) 48		
	@									
	@									
	@									
	@									

Temperature at ~~Port~~ Section (°F)

	Tangential Air	Axial Air	Primary Gas	Coal Transport Air	2	3	4 upper
Start	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	Burned	2012	1614
Finish	4.58 @ 45	1.0 @ 45	0.82 @ 2	— @ —	out	1974	1447

APPENDIX B

LIMB INNOVATIVE FURNACE PERFORMANCE EVALUATION AUDIT

ACUREX
Corporation

Environmental Systems Division

To: Judy Ford

From: Libby Beach

Date: December 16, 1991

Subject: LIMB Innovative Furnace PEA

Results were received Friday, December 13, from an internal performance evaluation audit (PEA) given on the LIMB Innovative Furnace. The purpose of the audit was to evaluate the performance of the furnace SO_2, O_2, and CO_2 CEM's. Two cylinders of known gas concentrations were delivered to the C-Wing facility on December 4, 1991, for analysis. The results were reported as follows:

	Analysis Required	Reported Concentration	Actual Concentration	%Difference
CYLINDER 1	SO_2	3189.8 ppm	3040.0 ppm	4.9
CYLINDER 2	O_2	9.93 %	10.0 %	0.7
	CO_2	11.72 %	12.0 %	2.3

Reported results are all well within the +/- 10% data quality objectives established in the project's QAPjP. No corrective actions were taken as a result of this audit.

cc K. Bruce
W. Hansen
G. Gillis
8420.266
8420.012

P.O. Box 13109, Research Triangle Park, NC 27709 • 4915 Prospectus Drive, Durham, NC 27713 (919) 544-4535 FAX: (919) 544-5690

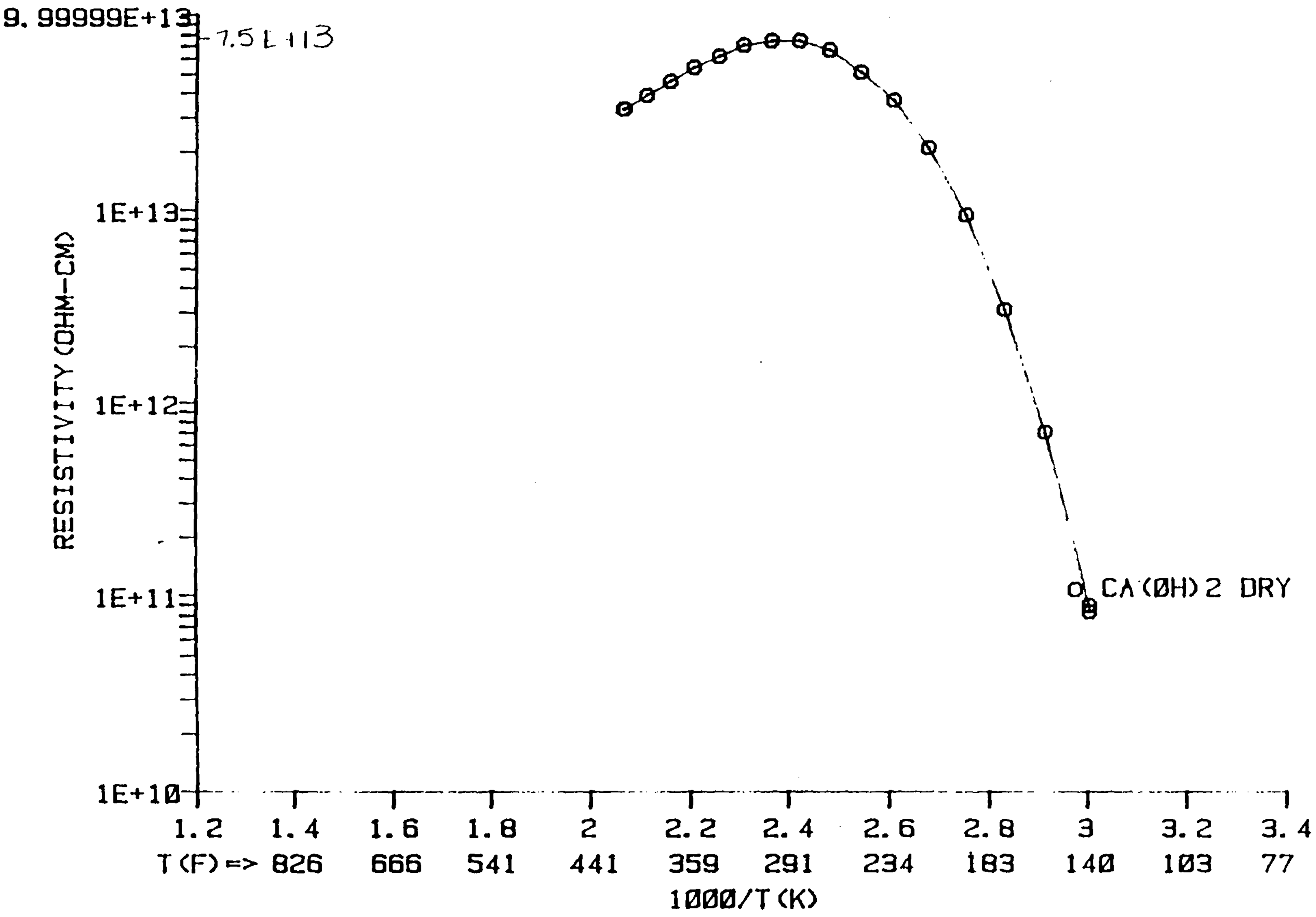
Division Headquarters

FAX: (415) 964-5146

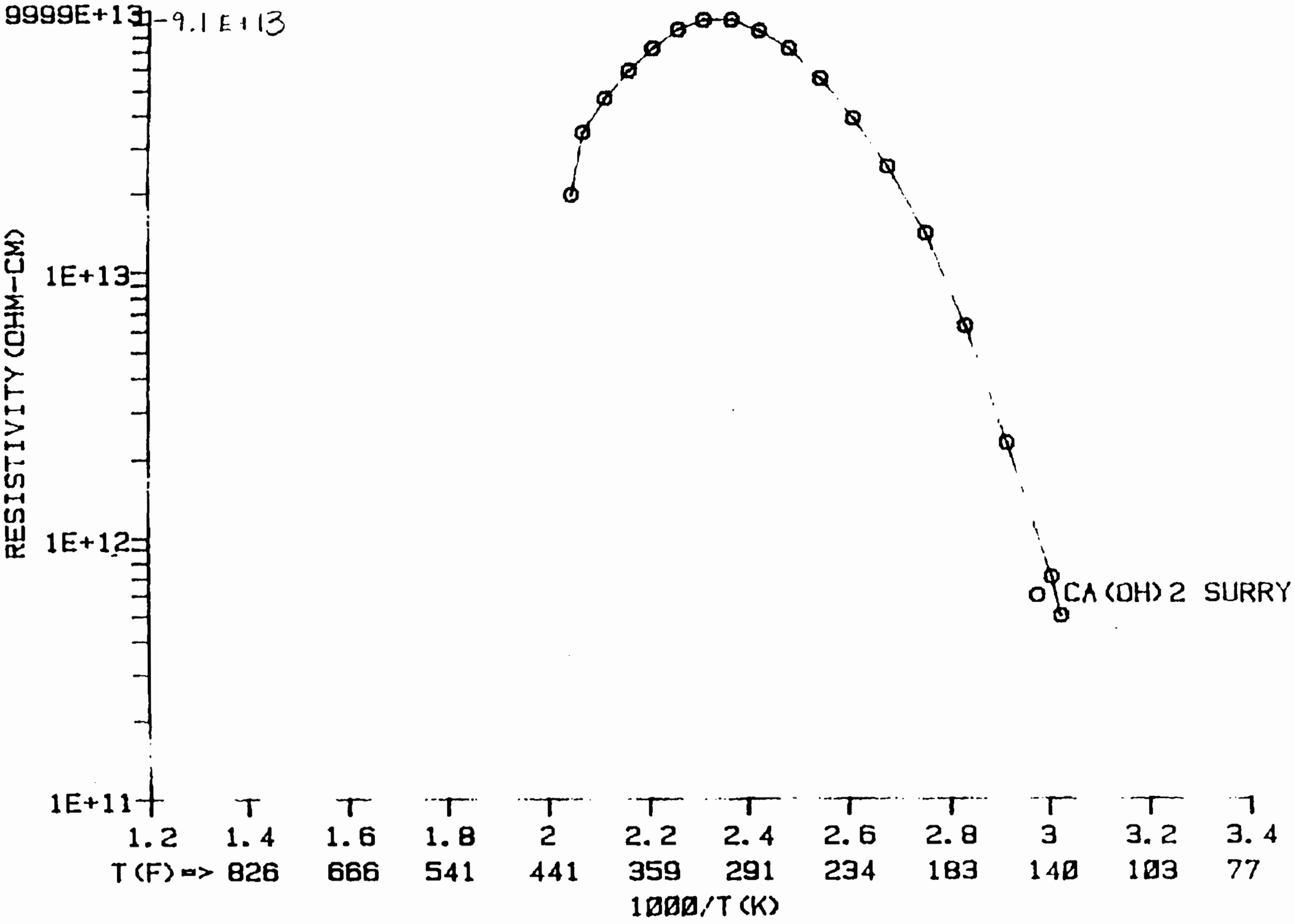
APPENDIX C

RESISTIVITY TEST RESULTS

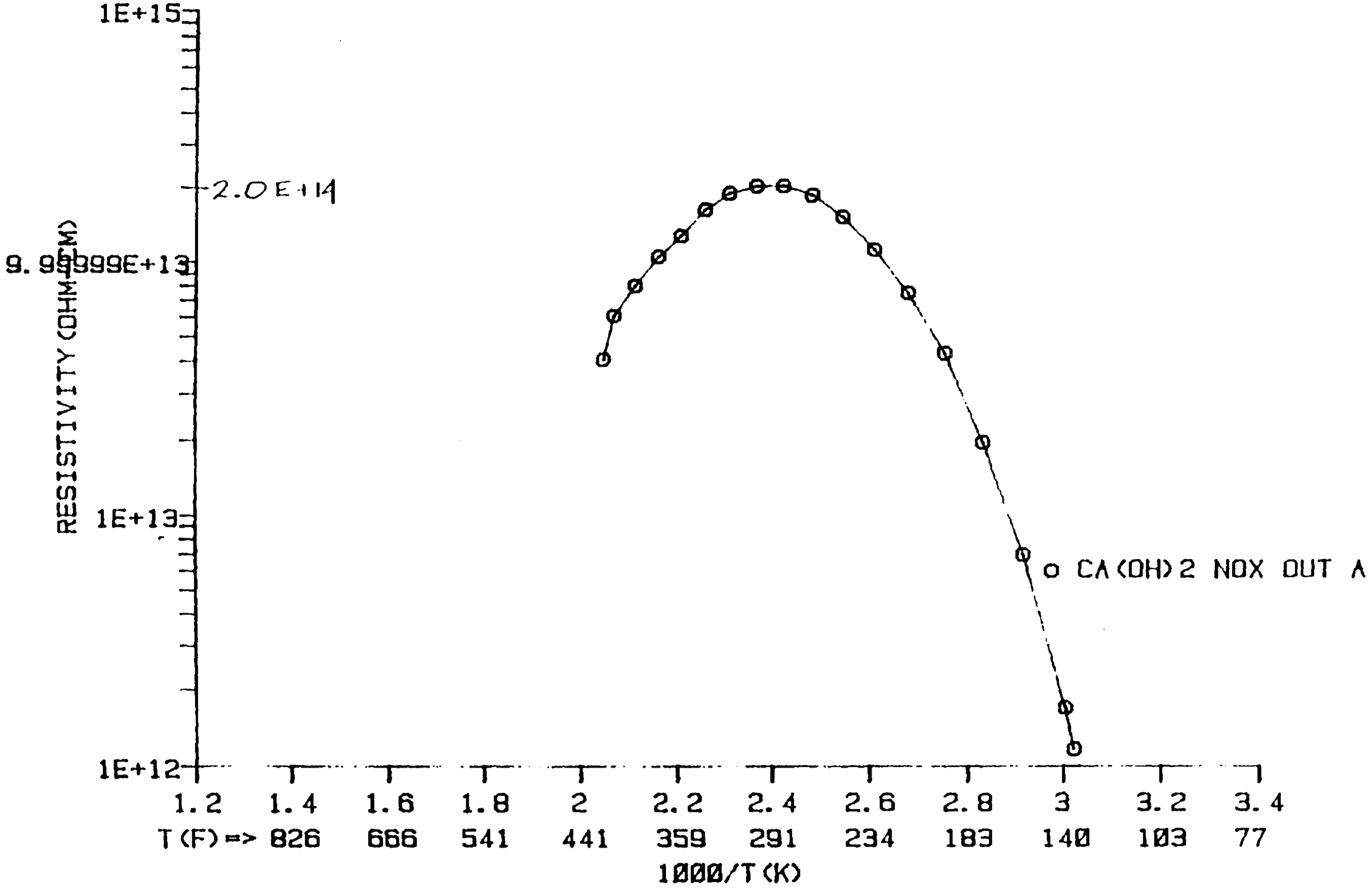
PITTS #8 &TENN
12/10/91
5% WATER



PITT#8 WITH TENN CUT
12/11/91
5% WATER



PITTS #8 TENN CUT
12/12/91
5% WATER



APPENDIX D

GRAPHICAL INTERPOLATION OF TEST RESULTS

Listing of Nalco/Fuel Tech Trial Runs(Original CRADA Scope of Work)

DATE	TRIAL	FIGURE	DESCRIPTION
12/03/90	N1	NFT1203A	NOXOUT A@2R VARYING NSR
12/04/90	N2	NFT1204A	NOXOUT A@3R VARYING NSR
12/05/90	N3	NFT1205A	NOXOUT A@3M VARYING NSR
12/05/90	N4	NFT1205B	NOXOUT A@4U VARYING NSR
12/06/90	N5	NFT1206A	same as above
12/07/90	N6	NFT1207A	NOXOUT A@3M VARYING NSR
12/12/90	N7	NFT1212A	NOXOUT A@3M VARYING NSR/XS OXYGEN
12/14/90	N8	NFT1214A	NOXOUT A@3M VARYING NSR, W/SO2 ADDED
12/19/90	N9	NFT1219A	NOXOUT A@3M VARYING NSR/XS OXYGEN
01/02/91	N10	NFT0102A	NOXOUT A@3M VARYING NSR
01/10/91	N11	NFT0110A	NOXOUT A@3M 1 NSR, VARY Ca/S(Ca(OH)2)
01/11/91	N12	NFT0111A	same as above
01/14/91	N13	NFT0114A	DRY Ca(OH)2@3M, VARY Ca/S
01/15/91	N14	NFT0115A	NOXOUT A@3R 1 NSR, VARY Ca/S(Ca(OH)2)
01/16/91	N15	NFT0116A	same as above
01/18/91	N16	NFT0121A	NOXOUT A@4U 1 NSR, VARY Ca/S(Ca(OH)2)
01/21/91	N17	NFT0121A	same as above
01/22/91	N18	NFT0122A	DRY Ca(OH)2@4U, VARY Ca/S
01/28/91	N19	NFT0128A	DRY Ca(OH)2@4L, VARY Ca/S
01/28/91	N20	NFT0128B	DRY Ca(OH)2@5, VARY Ca/S
01/30/91	N21	NFT0130B	DRY Ca(OH)2@6, VARY Ca/S
01/31/91	N22	********	NOXOUT A@4L 1 NSR, VARY Ca/S(Ca(OH)2)
02/05/91	N23	********	same as above
02/07/91	N24	NFT0208A	NOXOUT A@2R 1 NSR, VARY Ca/S(Ca(OH)2)
02/08/91	N25	NFT0208A	same as above
02/11/91	N26	NFT0213B	NOXOUT A@3M 1 NSR, VARY Ca/S(Ca(OH)2)
02/12/91	N27	NFT0212A	DRY Ca(OH)2@3M, VARY Ca/S
02/13/91	N28	NFT0213A	DRY Ca(OH)2@4U, VARY Ca/S
02/13/91	N29	NFT0213B	NOXOUT A@3M 1 NSR, VARY Ca/S(Ca(OH)2)
02/14/91	N30	NFT0214A	NOXOUT A@2R 1 NSR, VARY Ca/S(Ca(OH)2)
02/15/91	N31	NFT0327B	NOXOUT A@4L 1 NSR, VARY Ca/S(Ca(OH)2)
02/25/91	N32	NFT0228A	NOXOUT A@4U 1 NSR, VARY Ca/S(CaCO3)
02/27/91	N33	NFT0228A	same as above
02/28/91	N34	NFT0228A	same as above
03/01/91	N35	NFT0301A	DRY CaCO3@5, VARY Ca/S
03/22/91	N36	NFT0327A	NOXOUT A@4L 1 NSR, VARY Ca/S(Ca(OH)2)
03/27/91	N37	NFT0327A	same as above
03/28/91	N38	********	NOXOUT A@5 1 NSR, Ca/S≈3(Ca(OH)2)
03/29/91	N39	********	NOXOUT A@5 1 NSR, Ca/S≈2(Ca(OH)2)
04/01/91	N40	NFT0403A	NOXOUT A@4U 1 NSR, Ca/S≈2(Ca(OH)2)
04/02/91	N41	NFT0403A	NOXOUT A@4U 1 NSR, Ca/S≈3(Ca(OH)2)
04/03/91	N42	NFT0403A	NOXOUT A@4U 1 NSR, VARY Ca/S(Ca(OH)2)
04/04/91	N43	NFT0404A	DRY Ca(OH)2@6, VARY Ca/S
04/09/91	N44	NFT0409A	DRY CaCO3@4U VARY Ca/S
04/09/91	N45	NFT0409B	DRY CaCO3@5, VARY Ca/S
04/12/91	N46	NFT0412A	DRY CaCO3@3M, VARY Ca/S
04/15/91	N47	NFT0415A	DRY CaCO3@4L, VARY Ca/S
04/16/91	N48	NFT0416	DRY CaCO3@6, VARY Ca/S
04/16/91	N49	NFT0416A	DRY CaCO3@7, VARY Ca/S
04/17/91	N50	********	NOXOUT A@4U 1 NSR, VARY Ca/S(CaCO3)

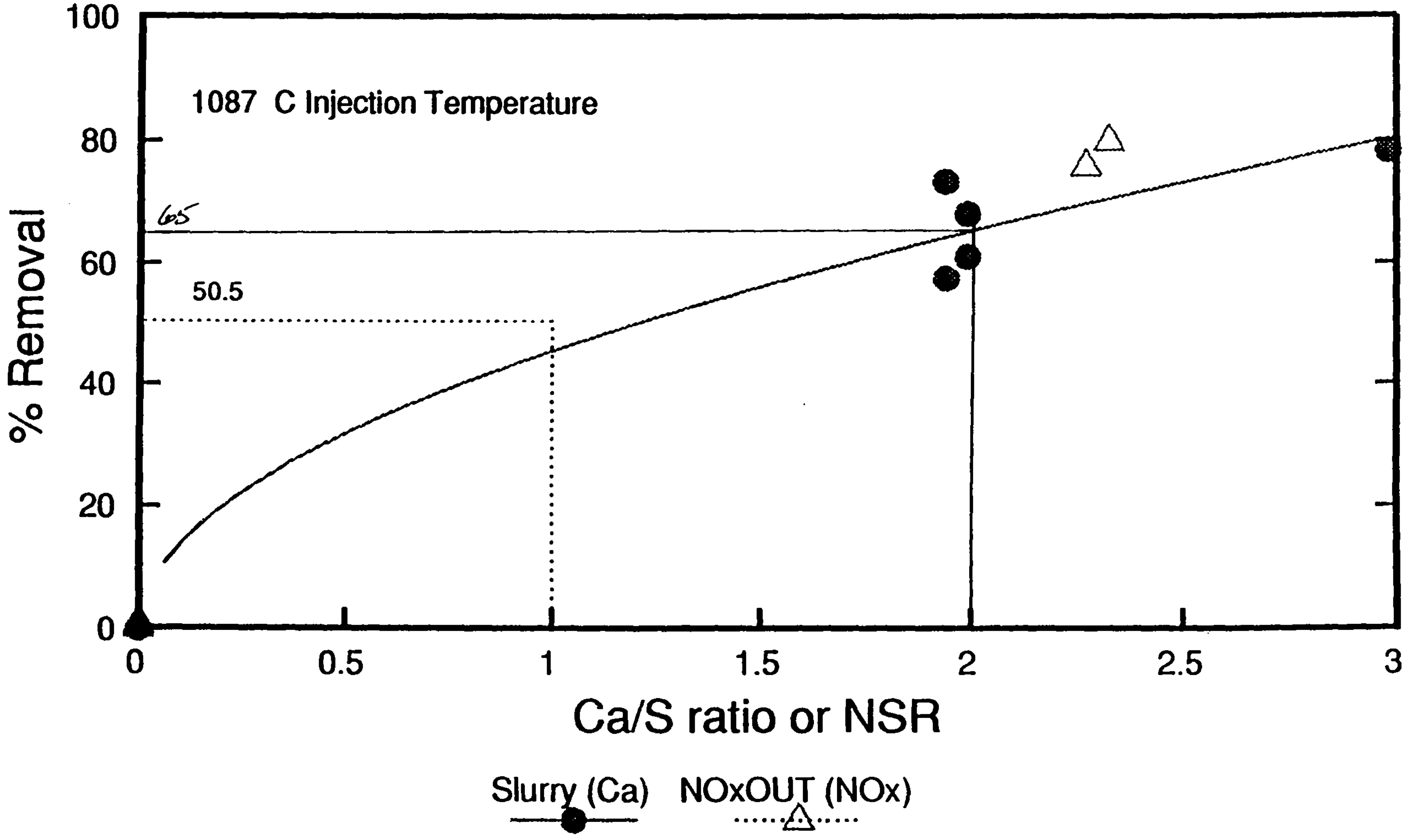
DATE	TRIAL	FIGURE	DESCRIPTION
04/18/91	N51	NFT0418A	NOXOUT A@4L 1 NSR, VARY Ca/S(CaCO3)
04/19/91	N52	NFT0419A	NOXOUT A@4L 1 NSR, VARY Ca/S(CaCO3)
04/22/91	N53	NFT0423A	NOXOUT A@3R 1 NSR, VARY Ca/S(CaCO3)
04/23/91	N54	NFT0423A	same as above
04/25/91	N55	********	DRY CaCO3@5, VARY Ca/S, D50<10µM
04/25/91	N56	NFT0426	NOXOUT A@4U 1 NSR, Ca/S≈3(CaCO3<10µm)
04/26/91	N57	NFT0426	NOXOUT A@4U 1 NSR, Ca/S≈2,1 (CaCO3<10µm)
04/29/91	N58	NFT0429	DRY CaCO3@5, VARY Ca/S, 75µm>D50>25µm
05/02/91	N59	NFT0502	NOXOUT A@4U 1 NSR, VARY Ca/S (75µm>CaCO3>25µm)
05/03/91	N60	NFT0503	NOXOUT A@4U 1 NSR, VARY Ca/S(SLAKED CaO)
05/06/91	N61	*******	NOXOUT A@4U 1 NSR, VARY Ca/S(CaCO3)
05/14/91	N62	NFT0502	NOXOUT A@4U 1 NSR, VARY Ca/S (75µm>CaCO3>25µm)
05/15/91	N63	NFT0502	same as above
05/16/91	N64	NFT0503A	NOXOUT A@4U 1 NSR, VARY Ca/S(SLAKED CaO)
05/31/91	QC1	NFT0531	DRY Ca(OH)2@5, Ca/S≈2, FOR QC CHECK
06/03/91	N65	*******	NOXOUT A+@4L 1 NSR, Ca/S≈2(Ca(OH)2)
06/04/91	N66	NFT0604	NOXOUT A@4L 1 NSR, Ca/S≈2(Ca(OH)2)
06/05/91	N67	*******	NOXOUT A@4U 1 NSR, Ca/S≈2(Ca(OH)2)
06/07/91	N68	*******	same as above
06/07/91	N69	*******	NOXOUT A@3M 1 NSR, Ca/S≈2(Ca(OH)2)
06/10/91	N70	*******	NOXOUT A@5 1 NSR, Ca/S≈2(Ca(OH)2)
06/11/91	N71	*******	NOXOUT A@5 1 NSR
06/11/91	N72	*******	NOXOUT A@4L 1 NSR
06/12/91	N73	*******	NOXOUT A@4U 1 NSR
06/12/91	N74	*******	NOXOUT A@3M 1 NSR
06/14/91	N75	*******	NOXOUT A&A+@4L 1 NSR, Ca/S≈2(Ca(OH)2, PITTS#8 COAL)
06/17/91	N76	*******	NOXOUT A&A+@4L 1 NSR, Ca/S≈1(Ca(OH)2, PITTS#8 COAL)
06/18/91	N77	*******	NOXOUT A@5 NSR≈1
06/18/91	N78	*******	NOXOUT A@4L NSR≈1
06/18/91	N79	*******	NOXOUT A@4U NSR≈1
06/19/91	N80	*******	NOXOUT A@3M NSR≈1
06/19/91	N81	*******	NOXOUT A@3R NSR≈1
06/19/91	N82	*******	NOXOUT A@2R NSR≈1

Listing of Nalco/Fuel Tech Trial Runs(Continuation Scope of Work)

DATE	TRIAL	FIGURE	DESCRIPTION
09/12/91	CN1	*********	NOXOUT A&A+@5 NSR≈1
09/13/91	CN2	*********	NOXOUT A&A+@4L NSR≈1
09/13/91	CN3	*********	NOXOUT A&A+@4U NSR≈1
09/13/91	CN4	*********	NOXOUT A&A+@3M NSR≈1
09/13/91	CN5	*********	NOXOUT A&A+@3R NSR≈1
09/16/91	CN6	*********	NOXOUT A&A+@2R NSR≈1
09/16/91	CN7	*********	NOXOUT A&A+@3M VARY NSR(≈1.0)
09/17/91	CN8	*********	NOXOUT A&A+@3M VARY NSR(≈0.5, 1.5)
09/17/91	CN9	*********	NOXOUT A&A+@3M VARY NSR(≈2.0)
09/21/91	CN10	*********	NOXOUT A@3M,3R NSR≈1, W/SO2
11/26/91	CN11	*********	NOXOUT A@3M NSR≈1, Ca/S≈3(Ca(OH)2)
11/27/91	CN12	*********	NOXOUT A+@3M NSR≈1, Ca/S≈3(Ca(OH)2)
12/02/91	CN13	*********	NOXOUT A&A+ NSR≈1, Ca/S≈2,1(Ca(OH)2)

Nalco Fueltech Test Results

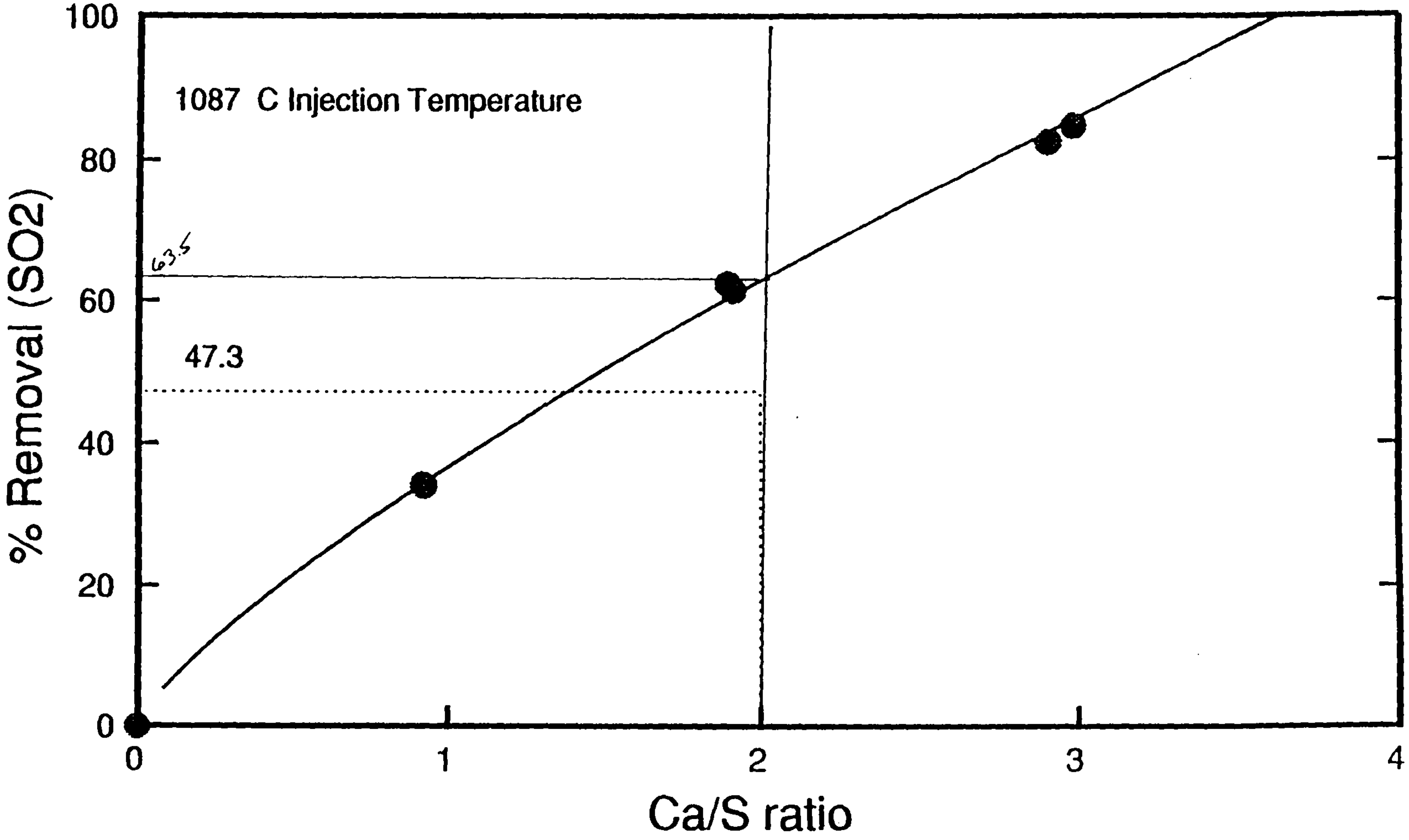
Ca(OH)2 slurry injected at Port 3M



1/10/91
NFT0110A.DRW
N11a & N11b

Nalco Fueltech Test Results

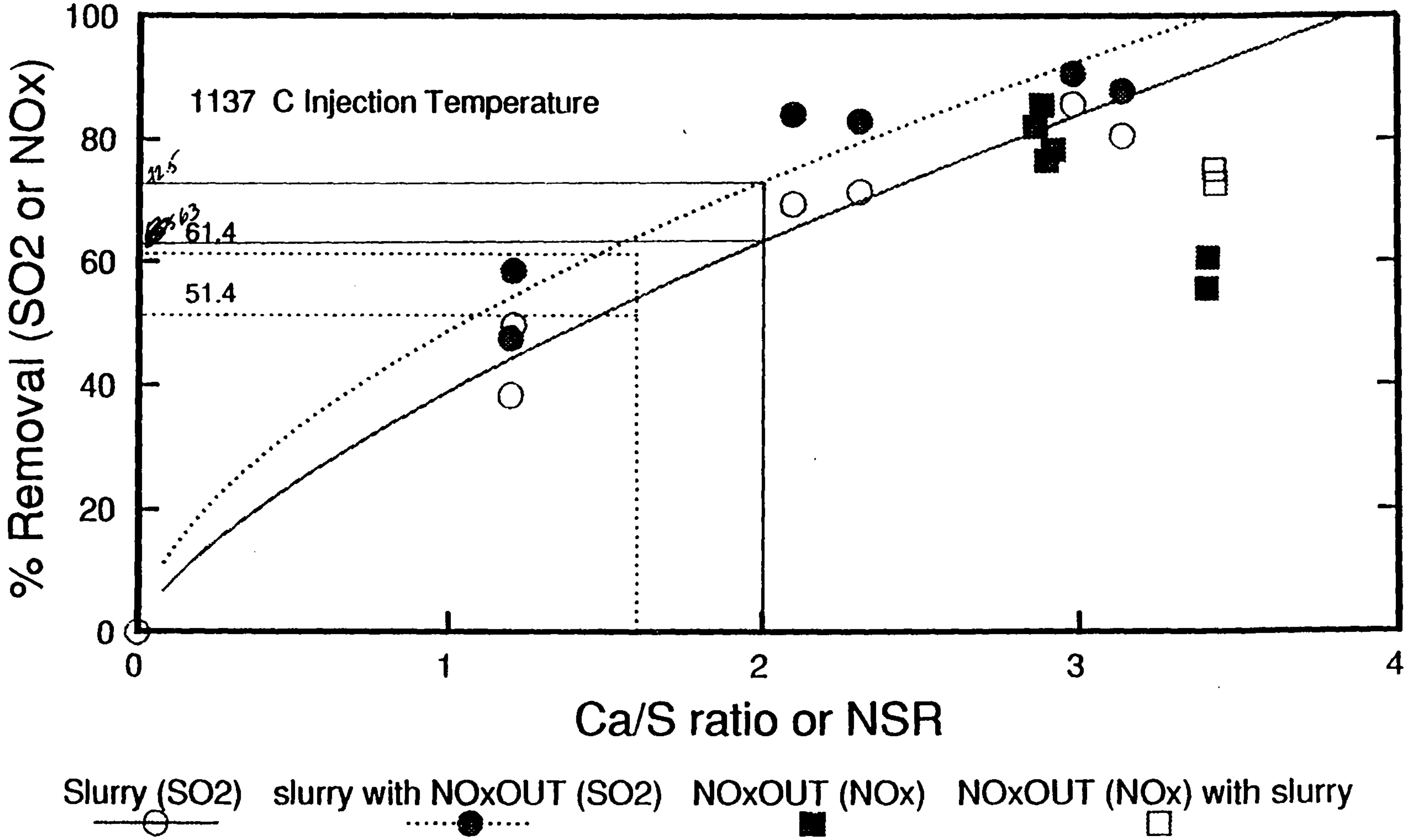
Dry Injection of Ca(OH)2 at port 3M



1/14/91
NFT0114A.DRW
N13

Nalco Fueltech Test Results

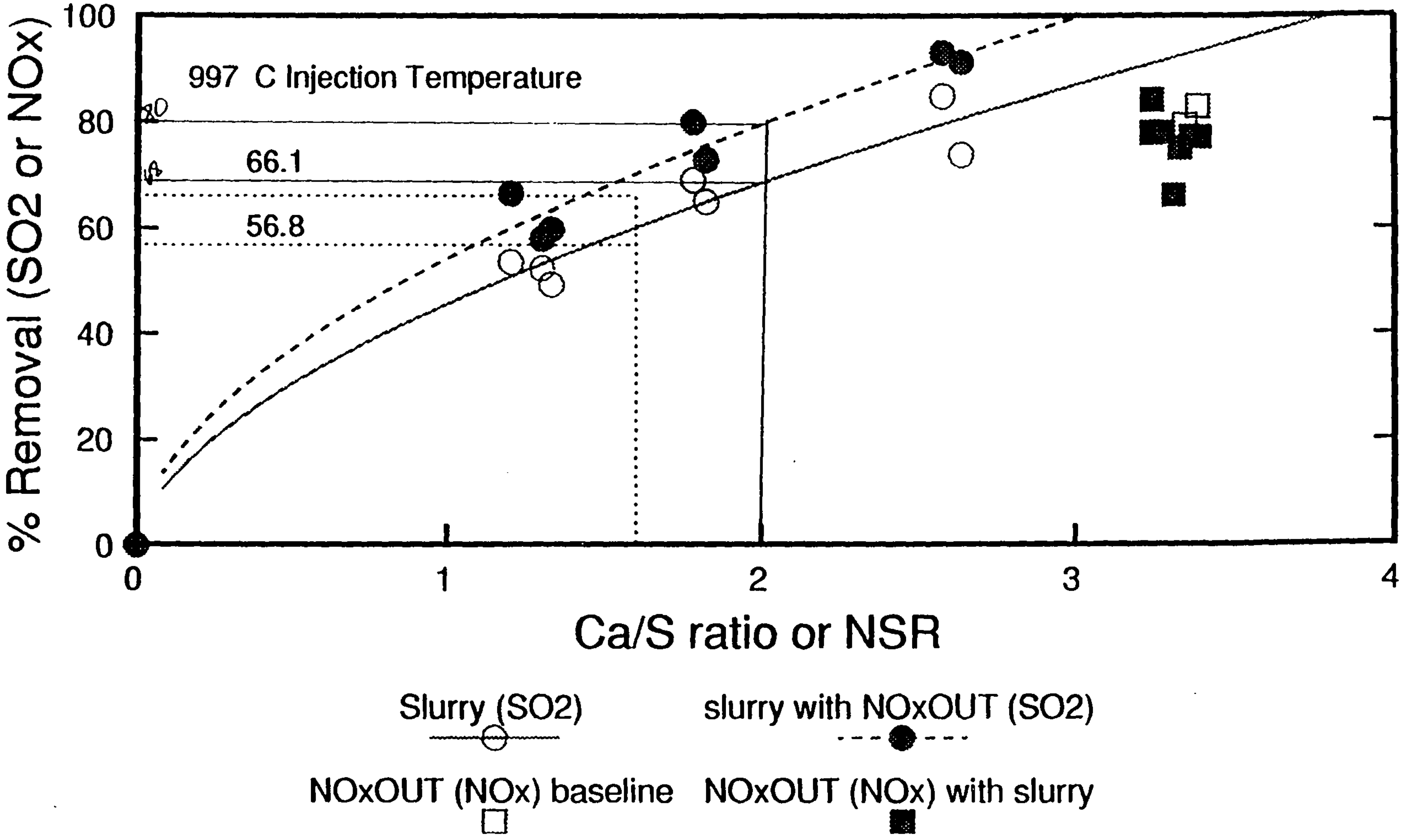
Ca(OH)2 slurry injected at Port 3R



1/15/91 and 1/16/91
NFT0116A.DRW
N14 & N15

Nalco Fueltech Test Results

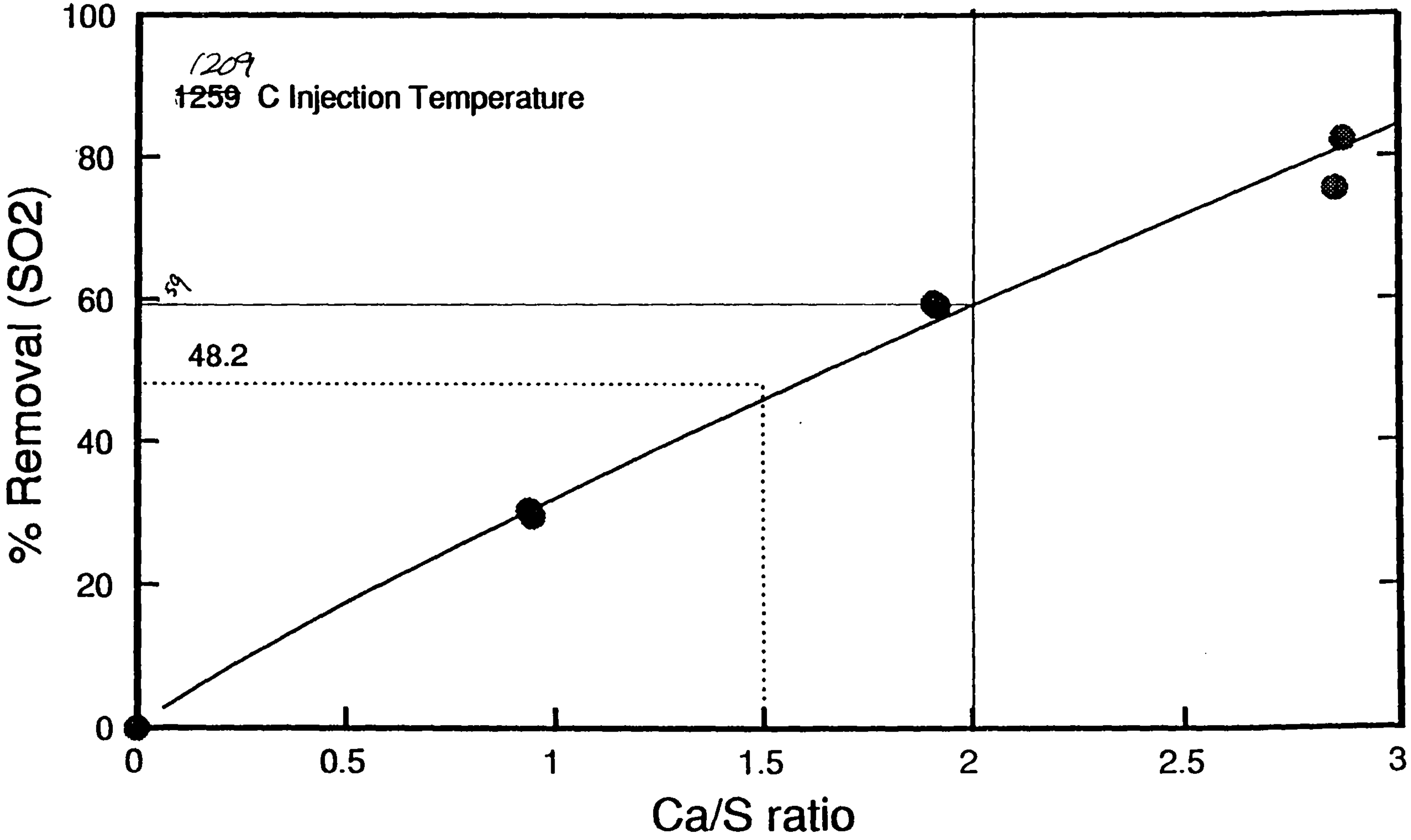
Ca(OH)2 slurry injected at Port 4U



1/18/91 and 1/21/91
NFT0121A.DRW
N16 & N17

Nalco Fueltech Test Results

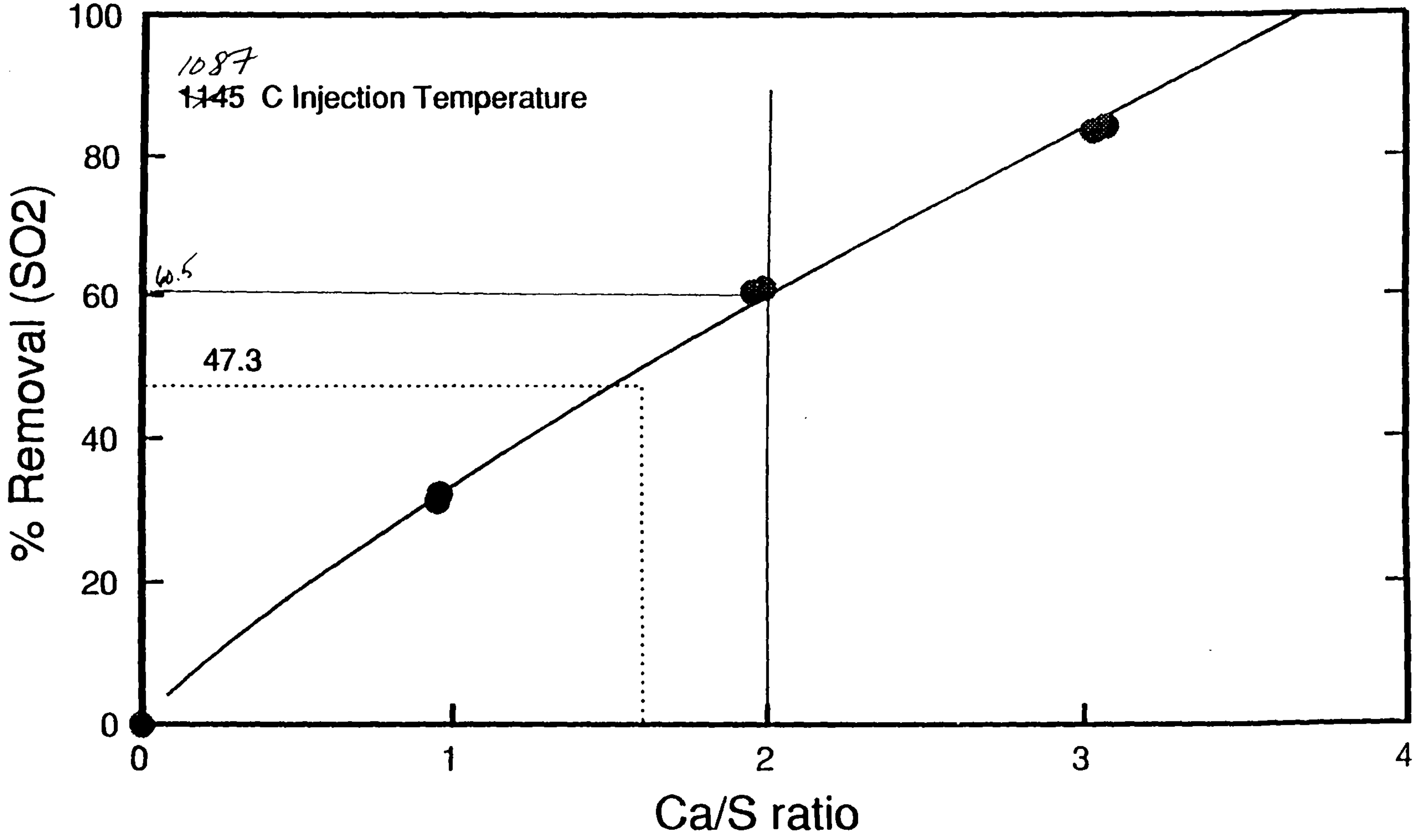
Dry Injection of Ca(OH)2 at port 4U



1/22/91
NFT0122A.DRW
N18

Nalco Fueltech Test Results

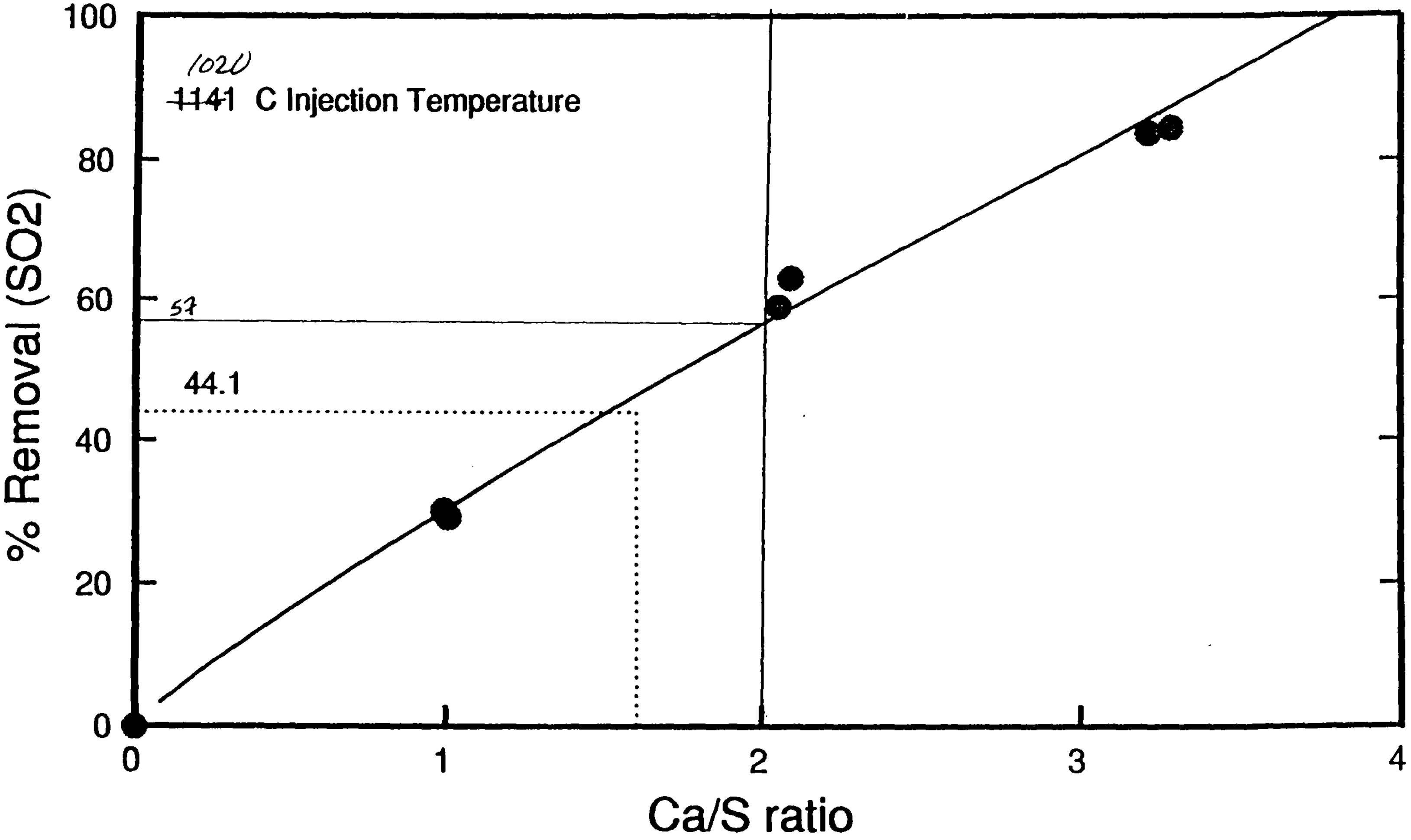
Dry Injection of $Ca(OH)_2$ at port 4L



1/28/91
NFT0128A.DRW
N19

Nalco Fueltech Test Results

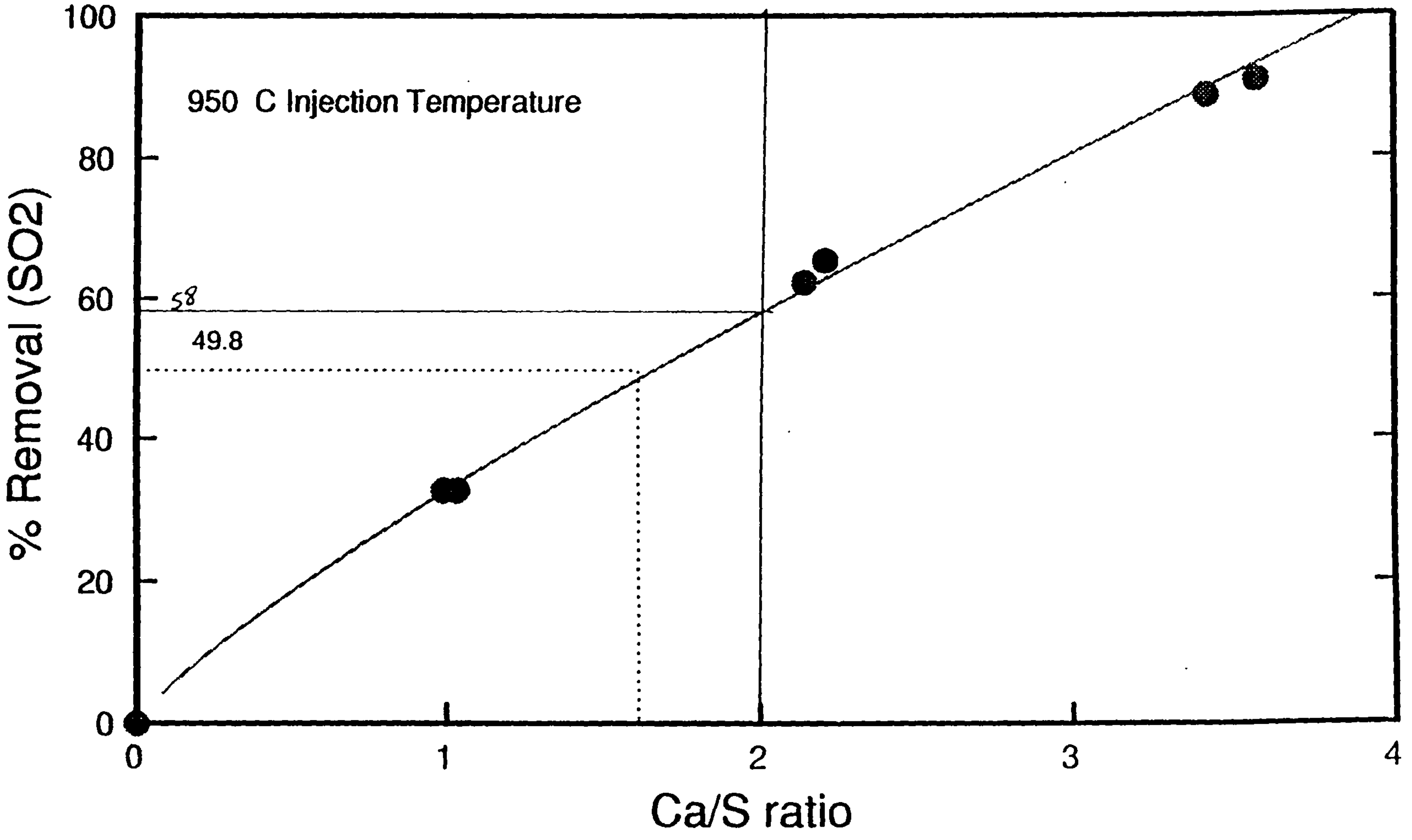
Dry Injection of Ca(OH)2 at port 5



1/28/91
NFT0128B.DRW
N20

Nalco Fueltech Test Results

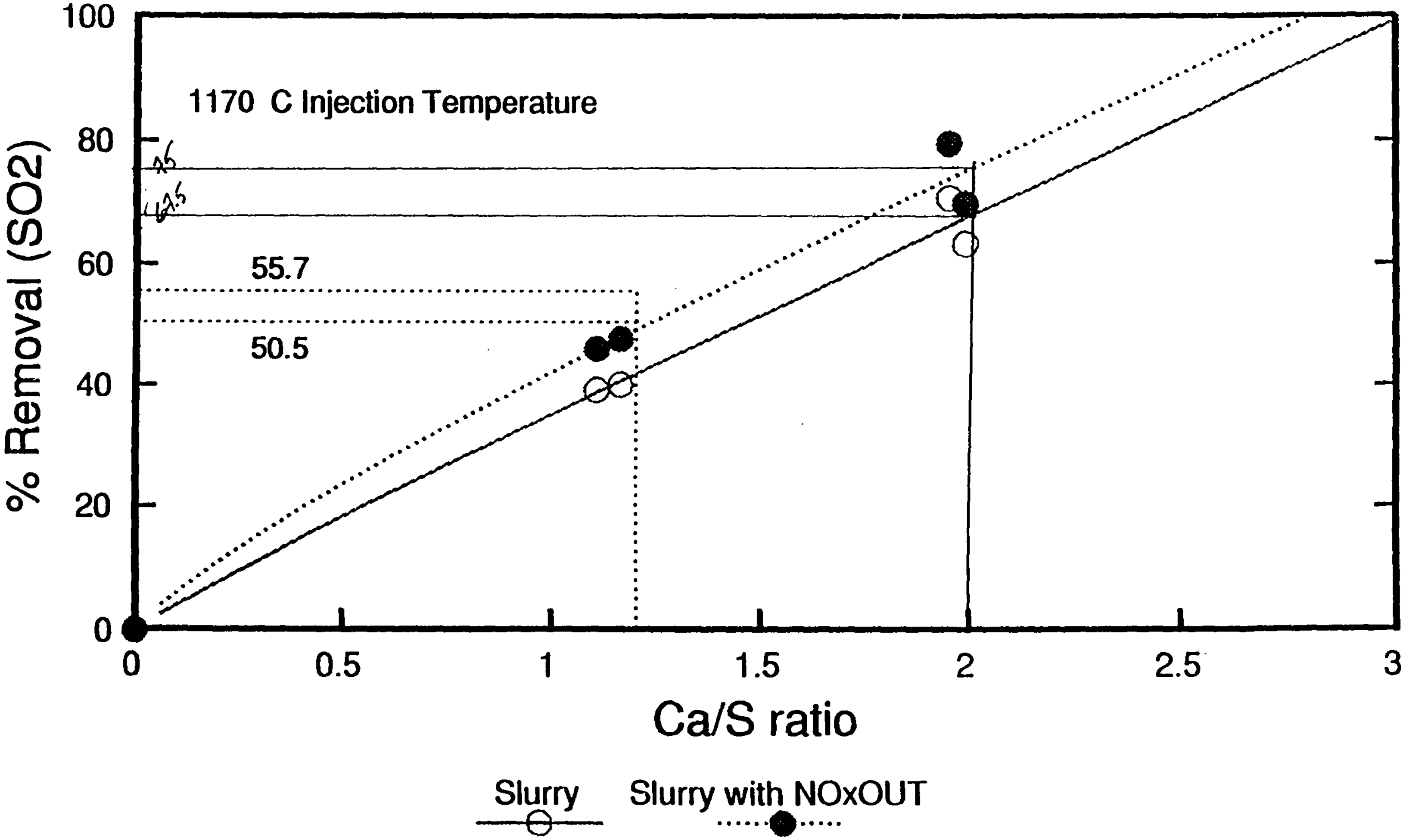
Dry Injection of Ca(OH)2 at port 6



1/30/91
NFT0130B.DRW
N21

Nalco Fueltech Test Results

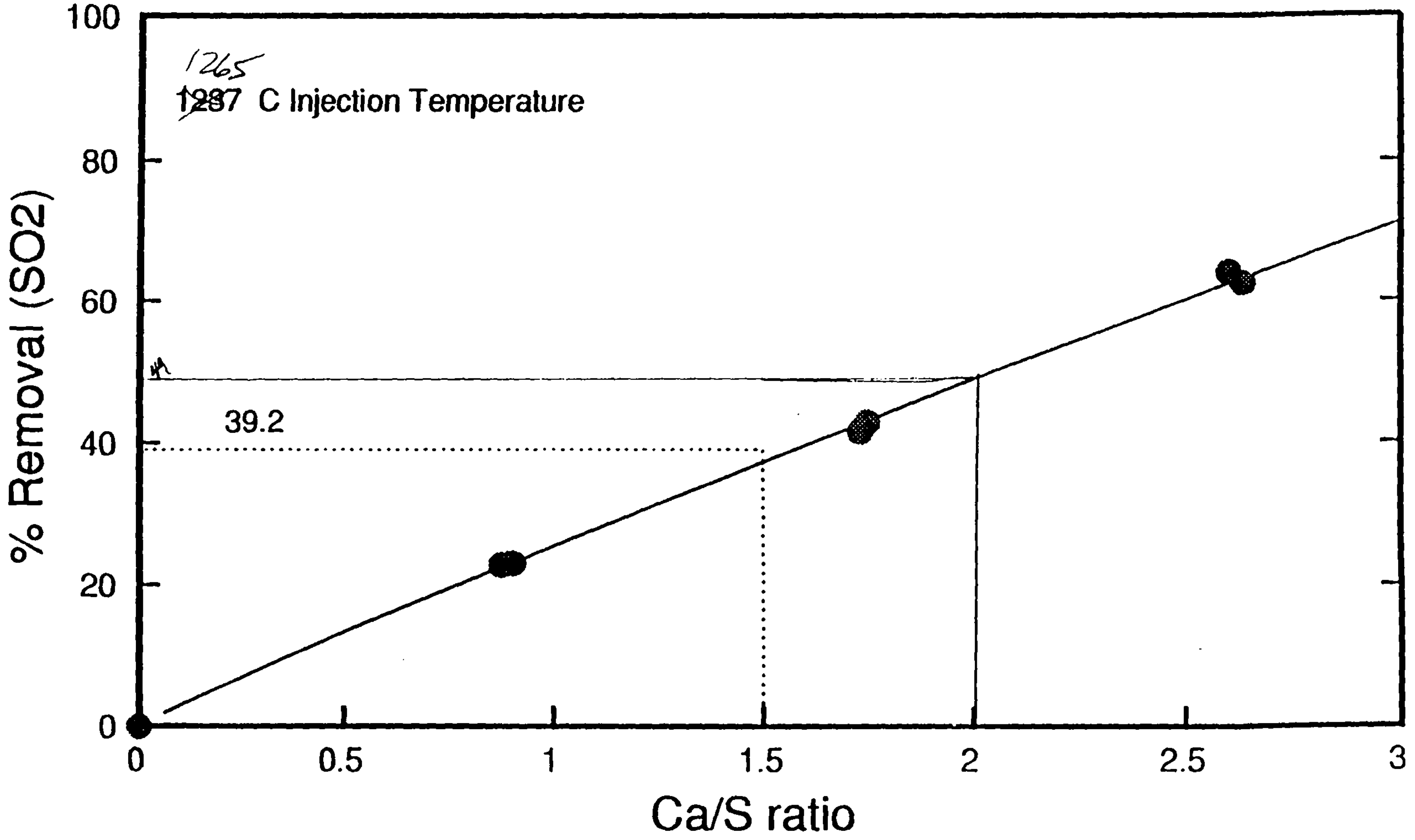
Ca(OH)2 slurry injected at Port 2R



2/7/91 and 2/8/91
NFT0208A.DRW
N24 & N25

Nalco Fueltech Test Results

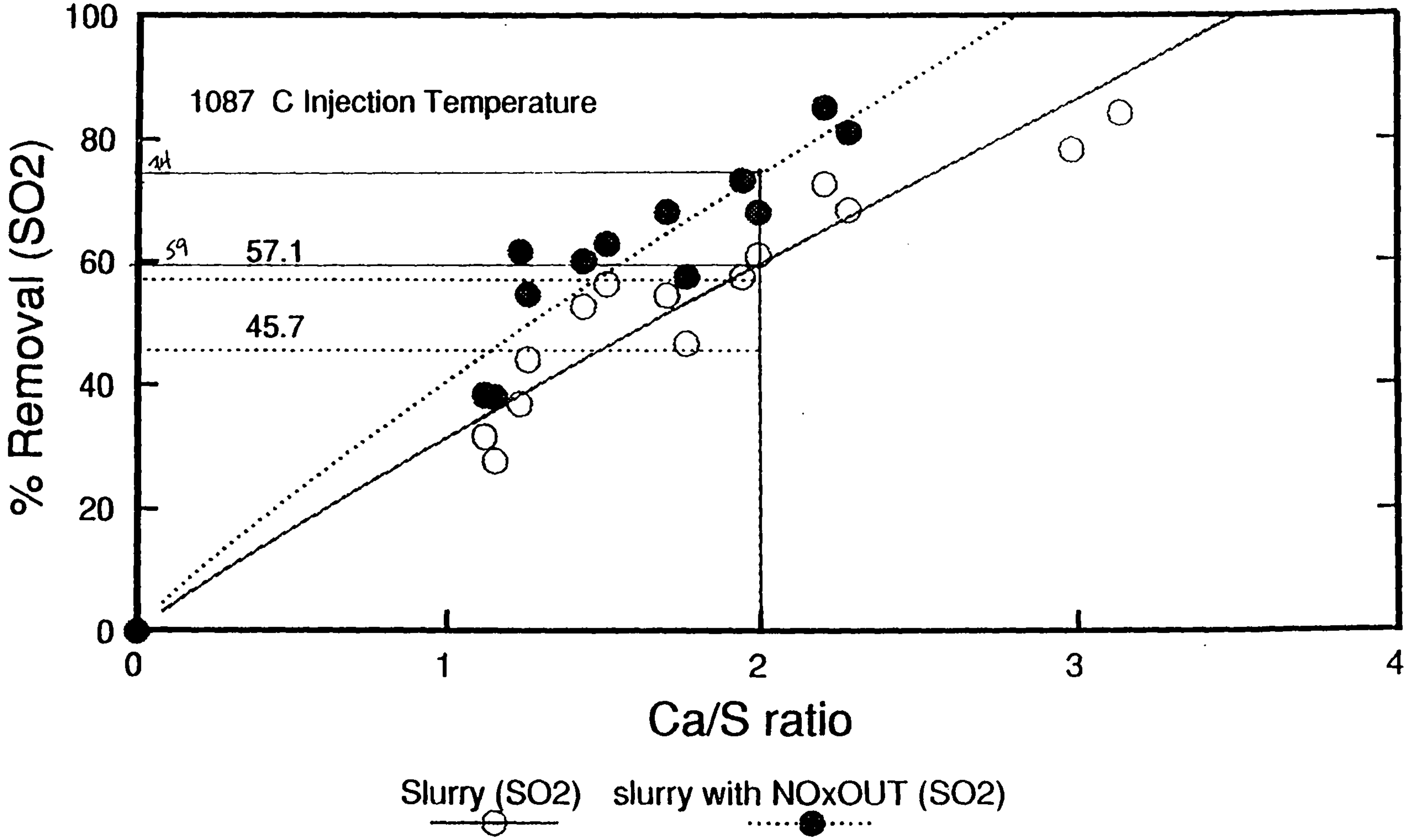
Dry Injection of Ca(OH)2 at port 3M



2/12/91
NFT0212A.DRW
N27

Nalco Fueltech Test Results

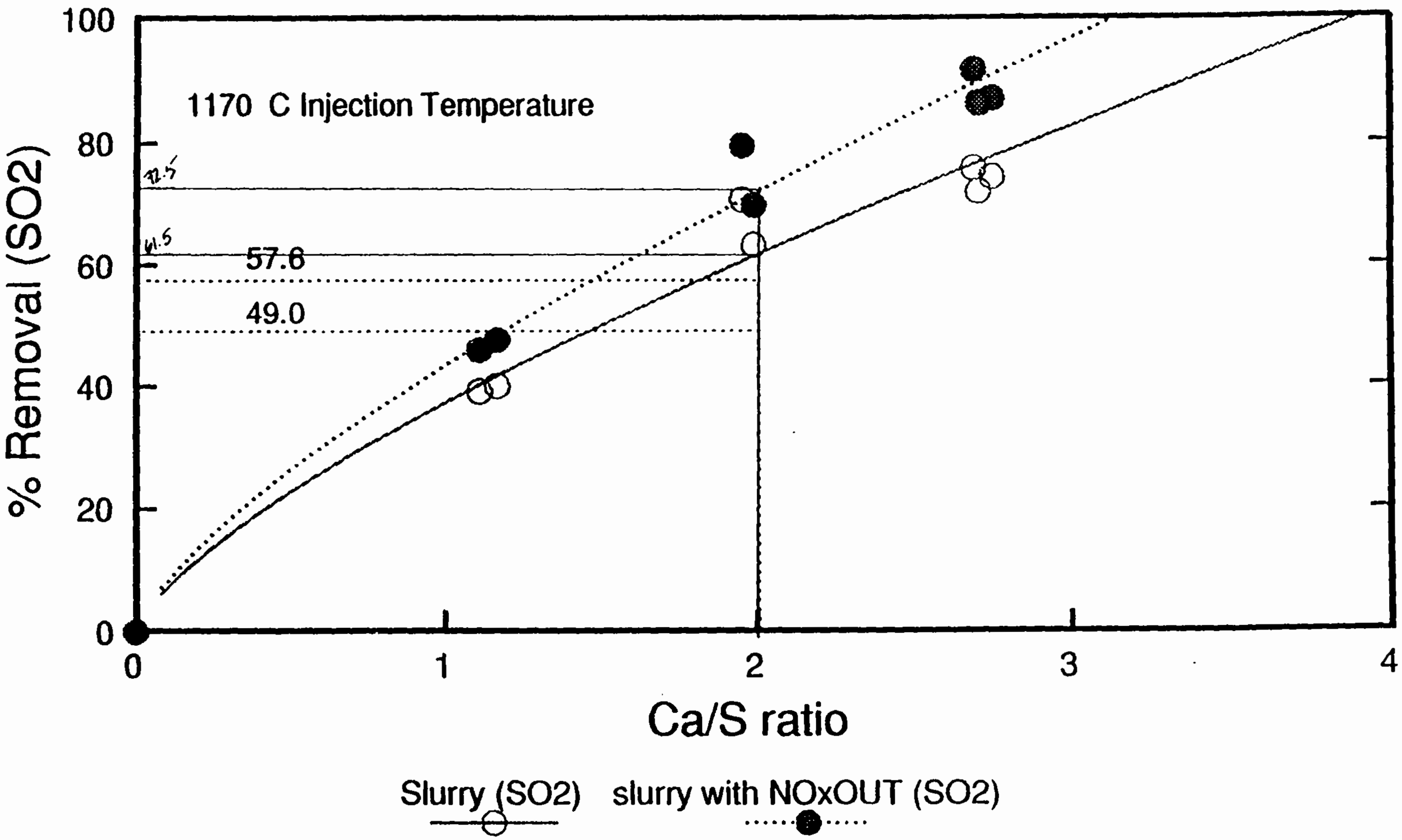
Ca(OH)2 slurry injected at Port 3M (repeats)



2/11/91, 2/13/91, 1/10/91, and 1/11/91
NFT0213B.DRW
N11, N12, N26, & N29

Nalco Fueltech Test Results

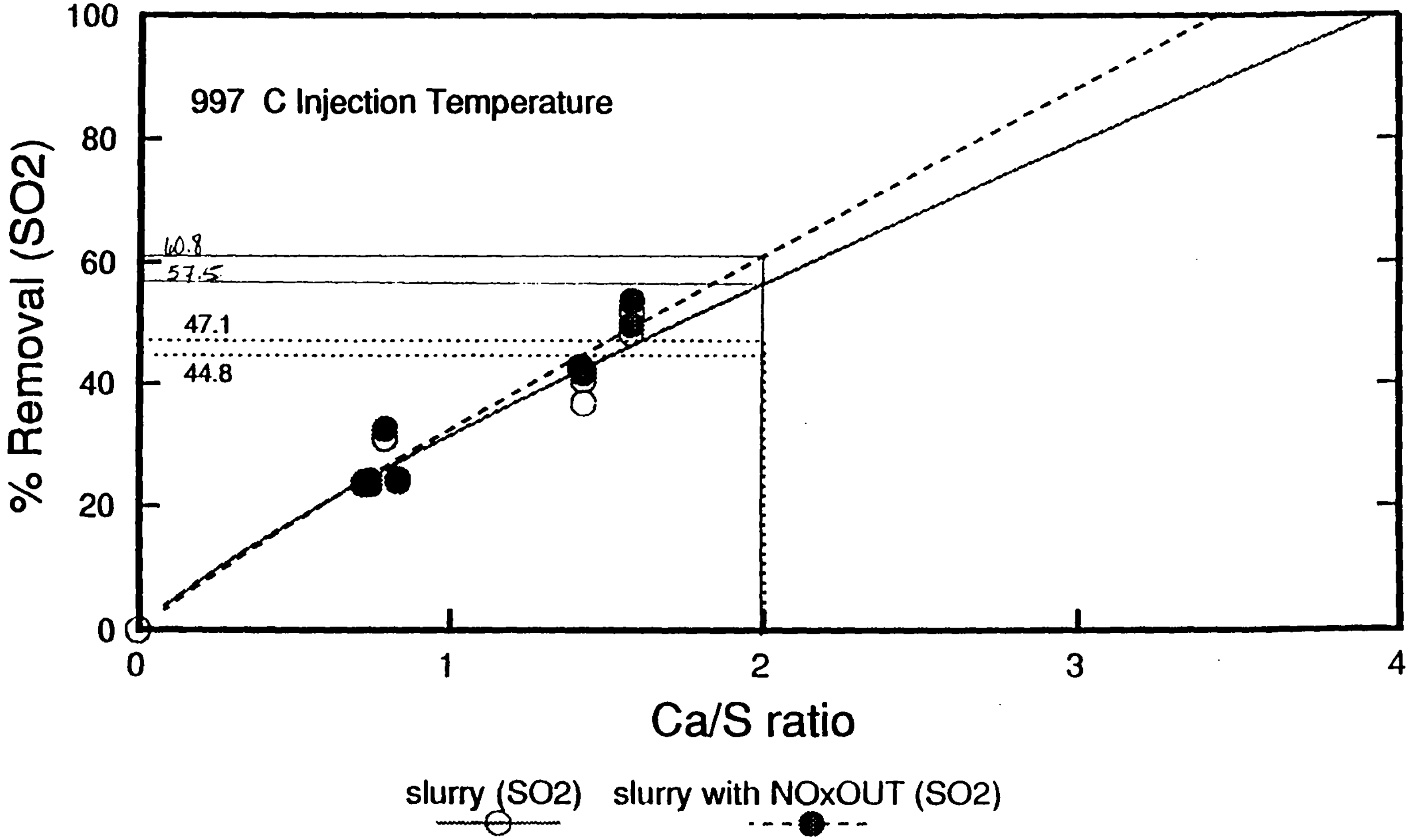
Ca(OH)2 slurry injected at Port 2R



2/7/91, 2/8/91, and 2/14/91
NFT0214A.DRW
N24, N25, & N30

Nalco Fueltech Test Results

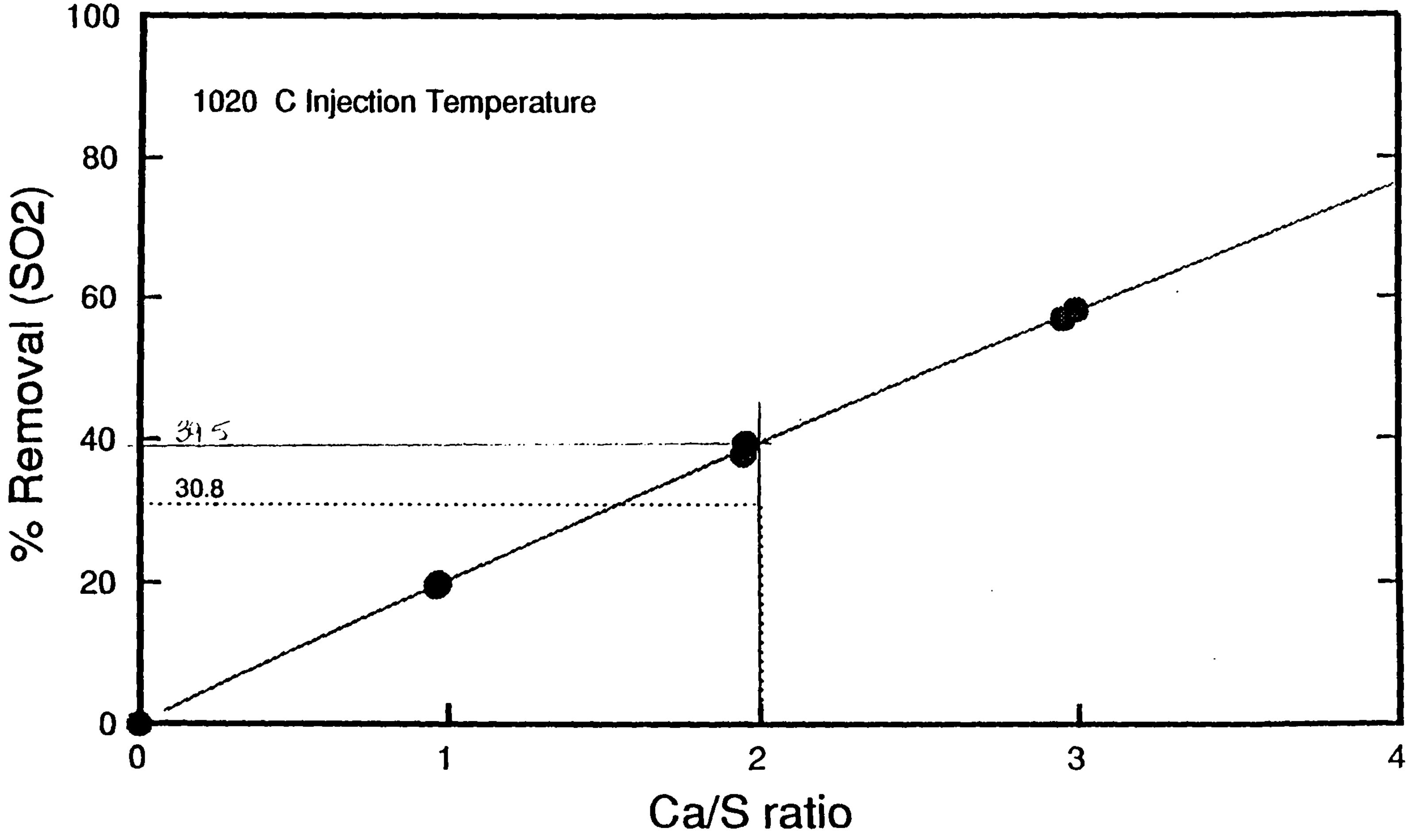
As received CaCO3 slurry injected as 4U



2/25/91, 2/27/91 and 2/28/91
NFT0228A.DRW
N32, N33, & N34

Nalco Fueltech Test Results

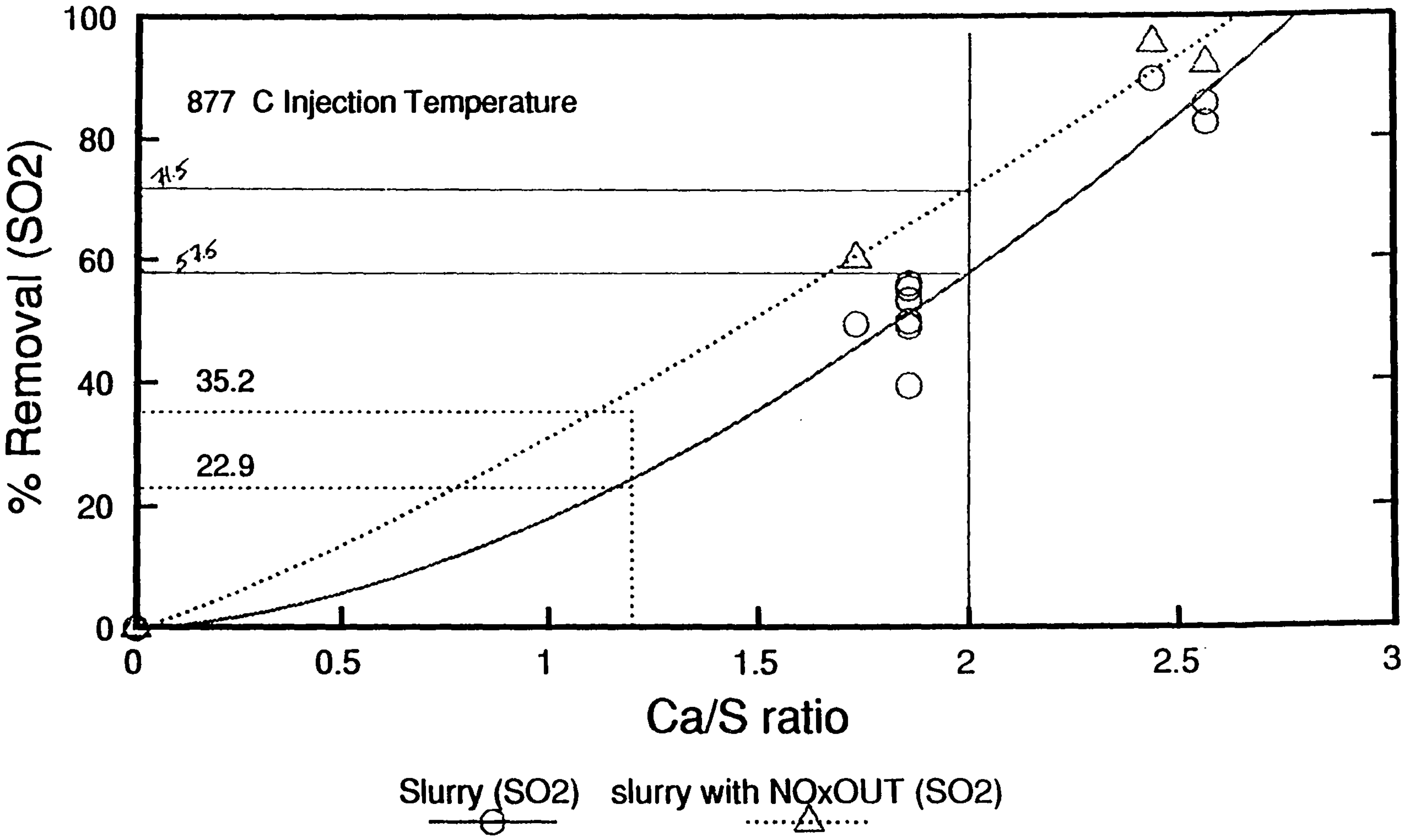
Dry Injection of as received CaCO3 Port 5



3/01/91
NFT0301A.DRW
N35

Nalco Fueltech Test Results

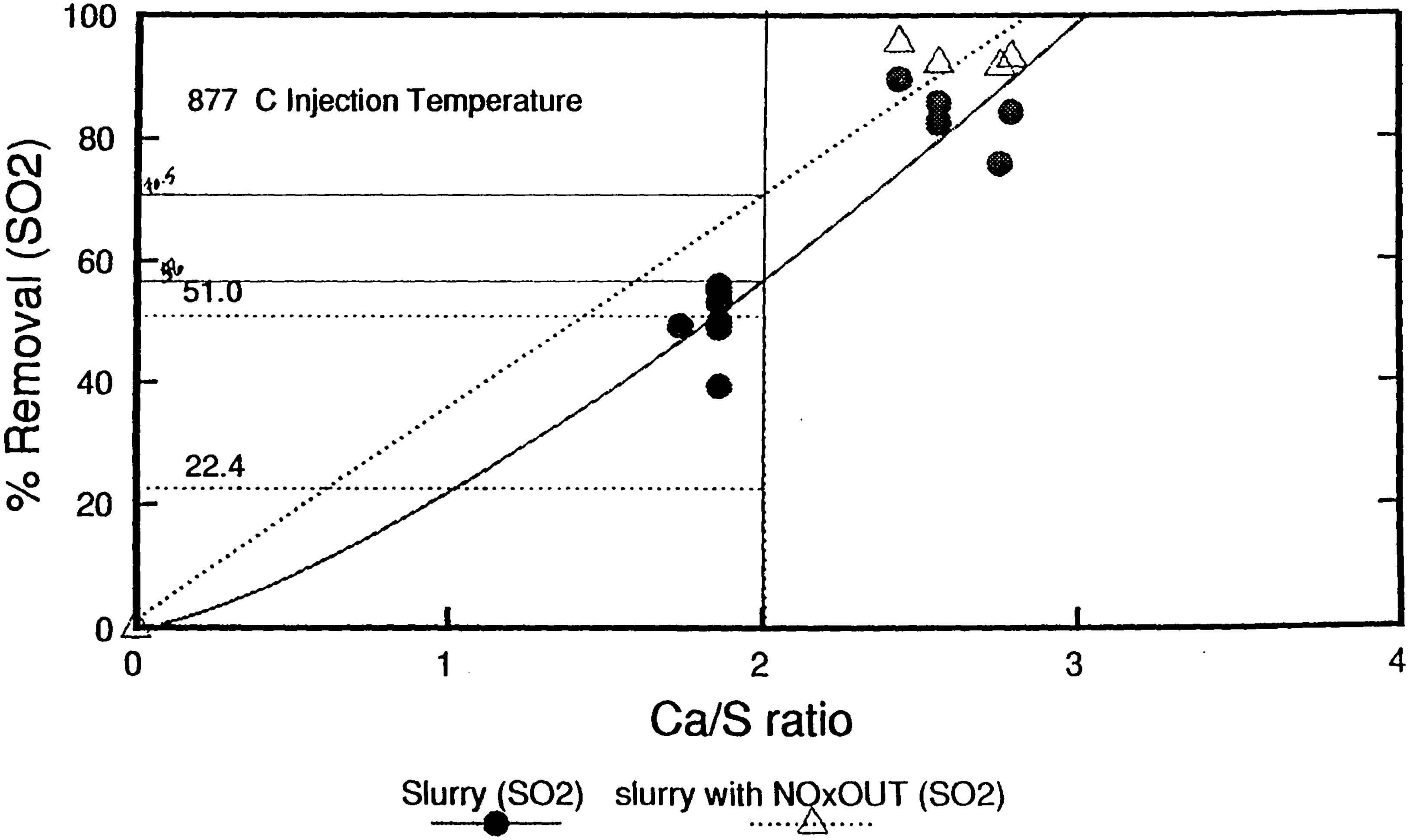
Ca(OH)2 slurry injected at Port 4L (repeats)



3/22/91 and 3/27/91
NFT0327A.DRW
N36 & N37

Nalco Fueltech Test Results

Ca(OH)2 slurry injected at Port 4L

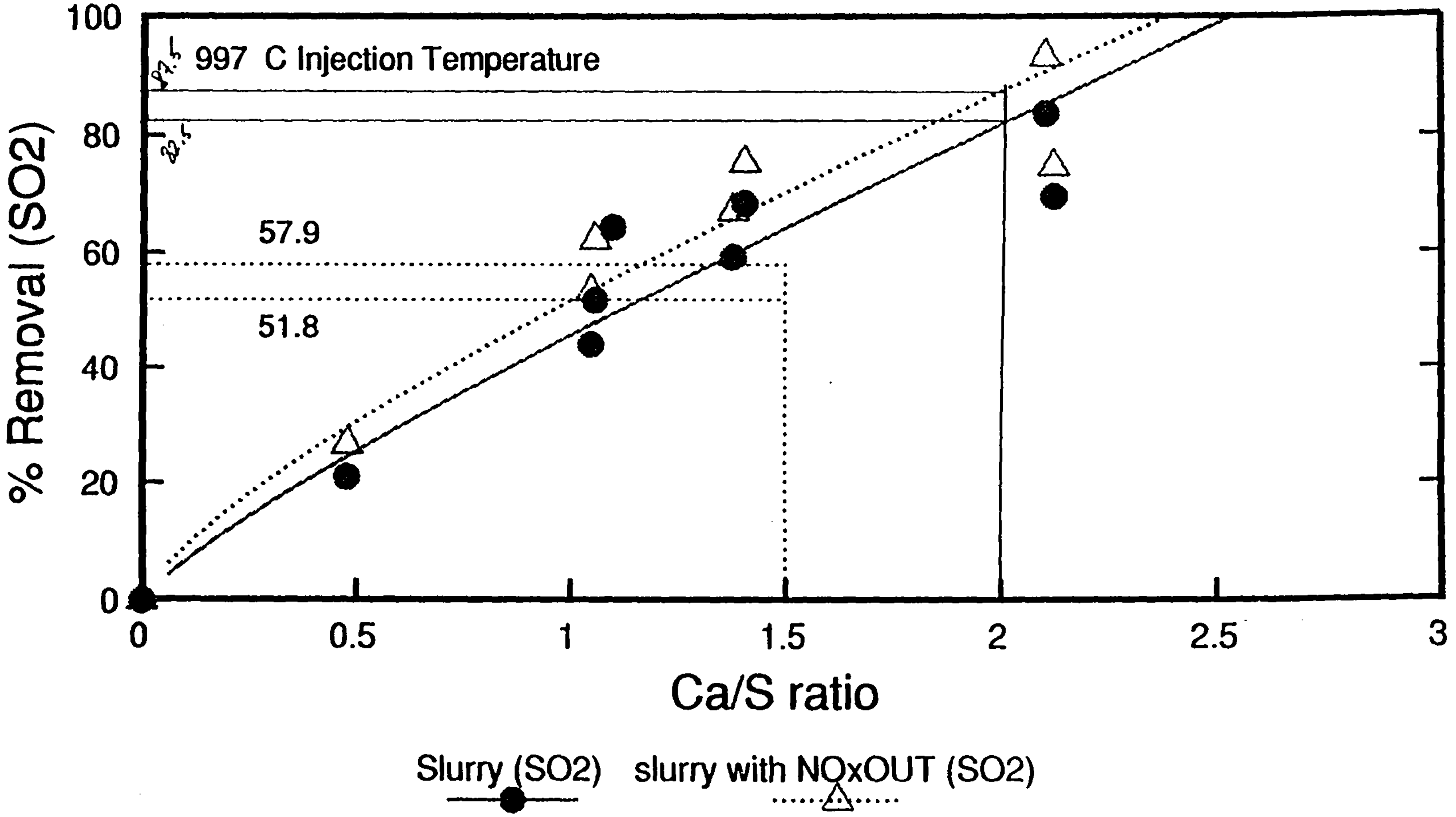


2/15/91, 3/22/91, and 3/27/91
NFT0327B.DRW
N31, N36 & N37

Nalco Fueltech Test Results

Ca(OH)2 slurry injected at Port 4U

(repeat tests)

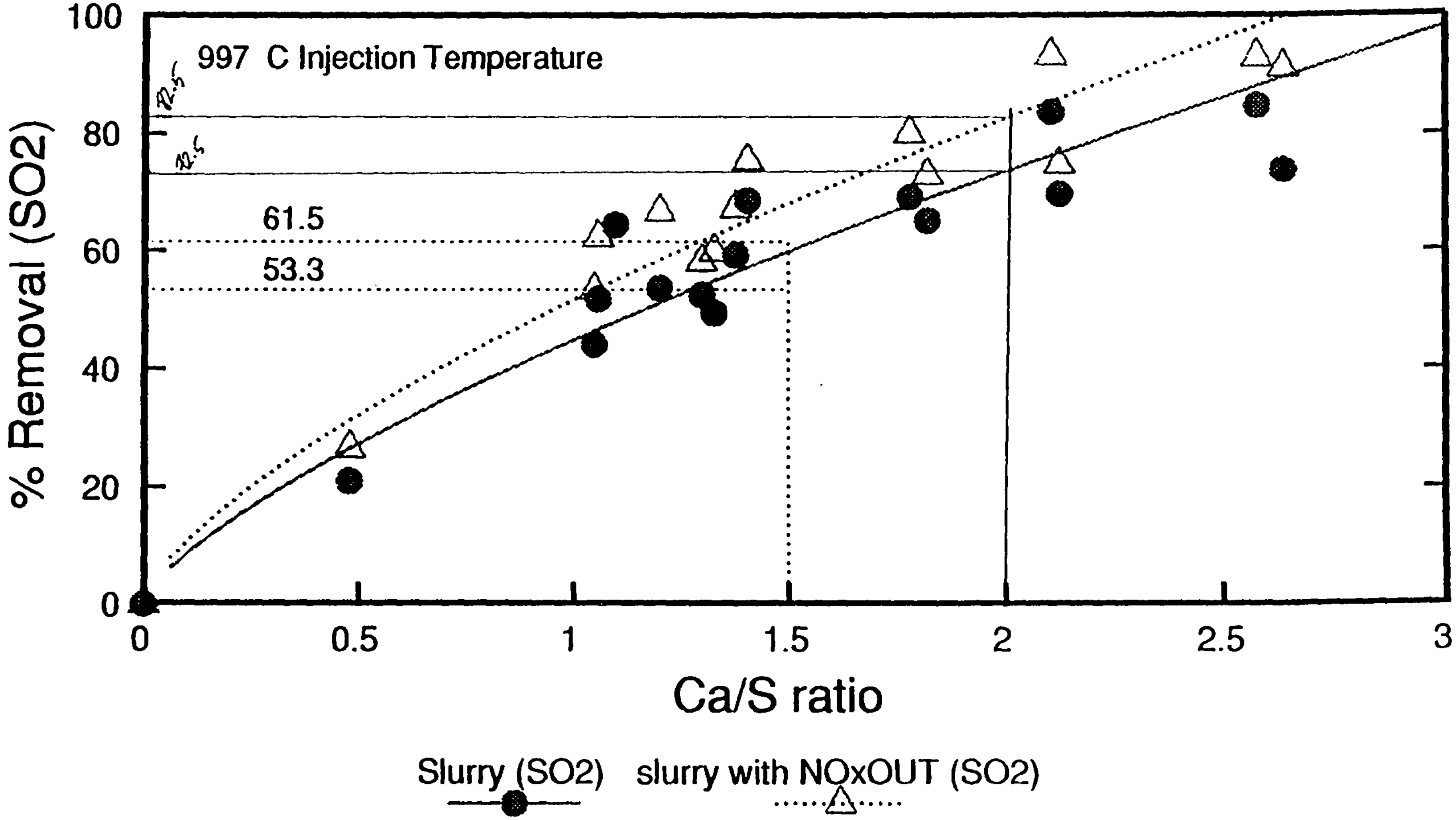


4/1/91, 4/2/91, and 4/3/91
NFT0403A.DRW
N40, N41 & N42

Nalco Fueltech Test Results

Ca(OH)2 slurry injected at Port 4U

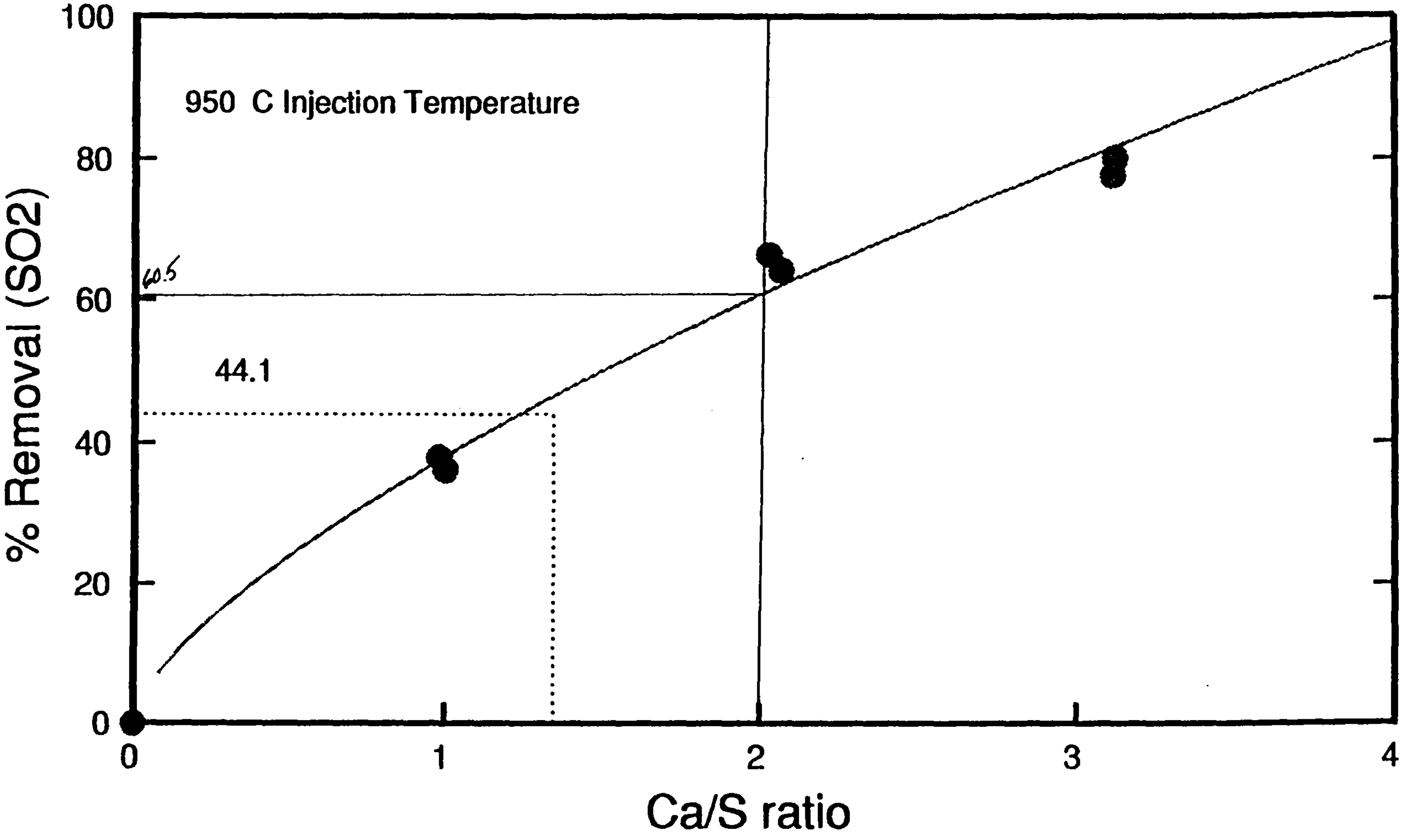
all tests



4/1/91, 4/2/91, 4/3/91, 1/18/91, and 1/21/91
NFT0403B.DRW
N40, N41, N42, N16 & N17

Nalco Fueltech Test Results

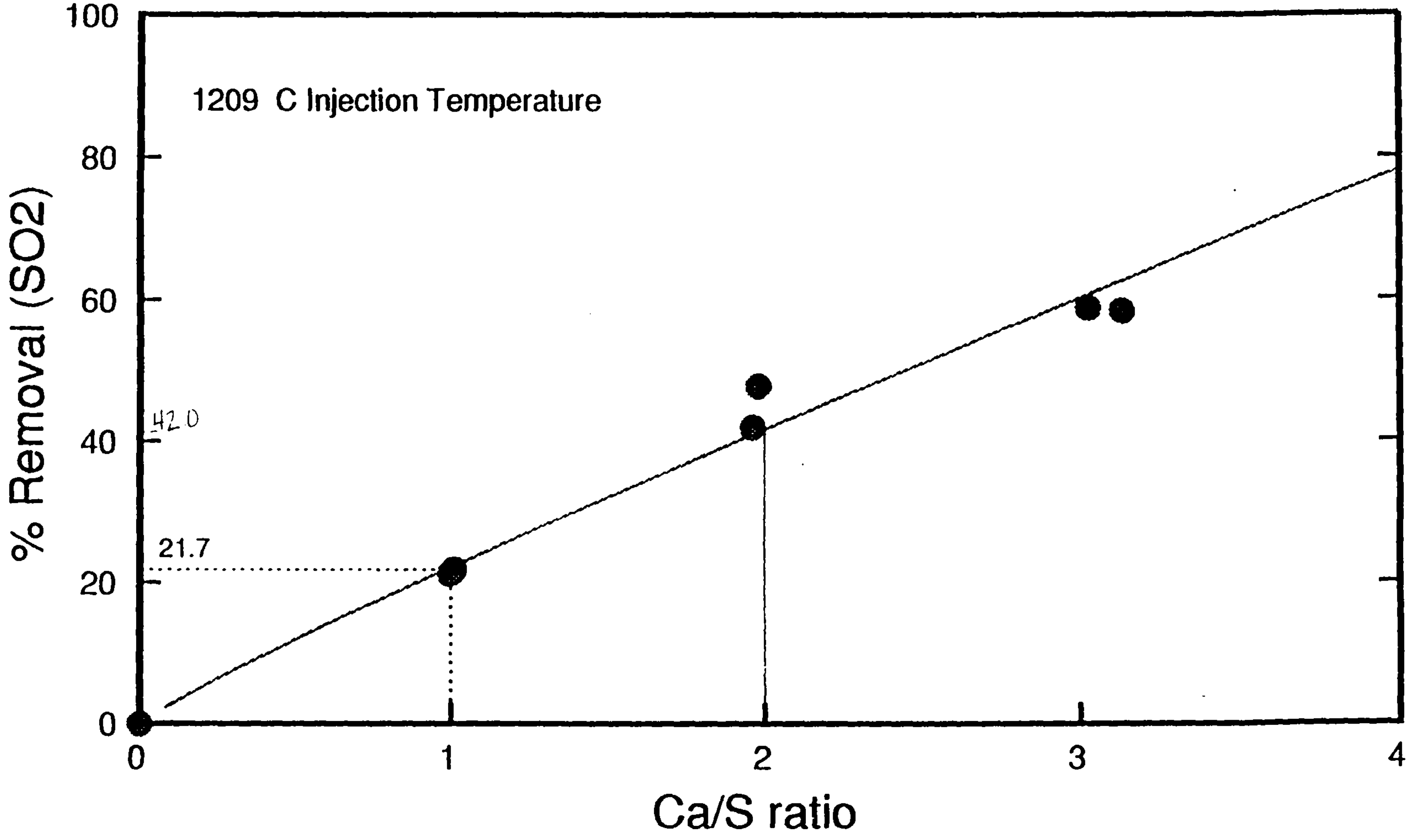
Dry Injection of Ca(OH)2 at Port 6



4/4/91
NFT0404A.DRW
N43

Nalco Fueltech Test Results

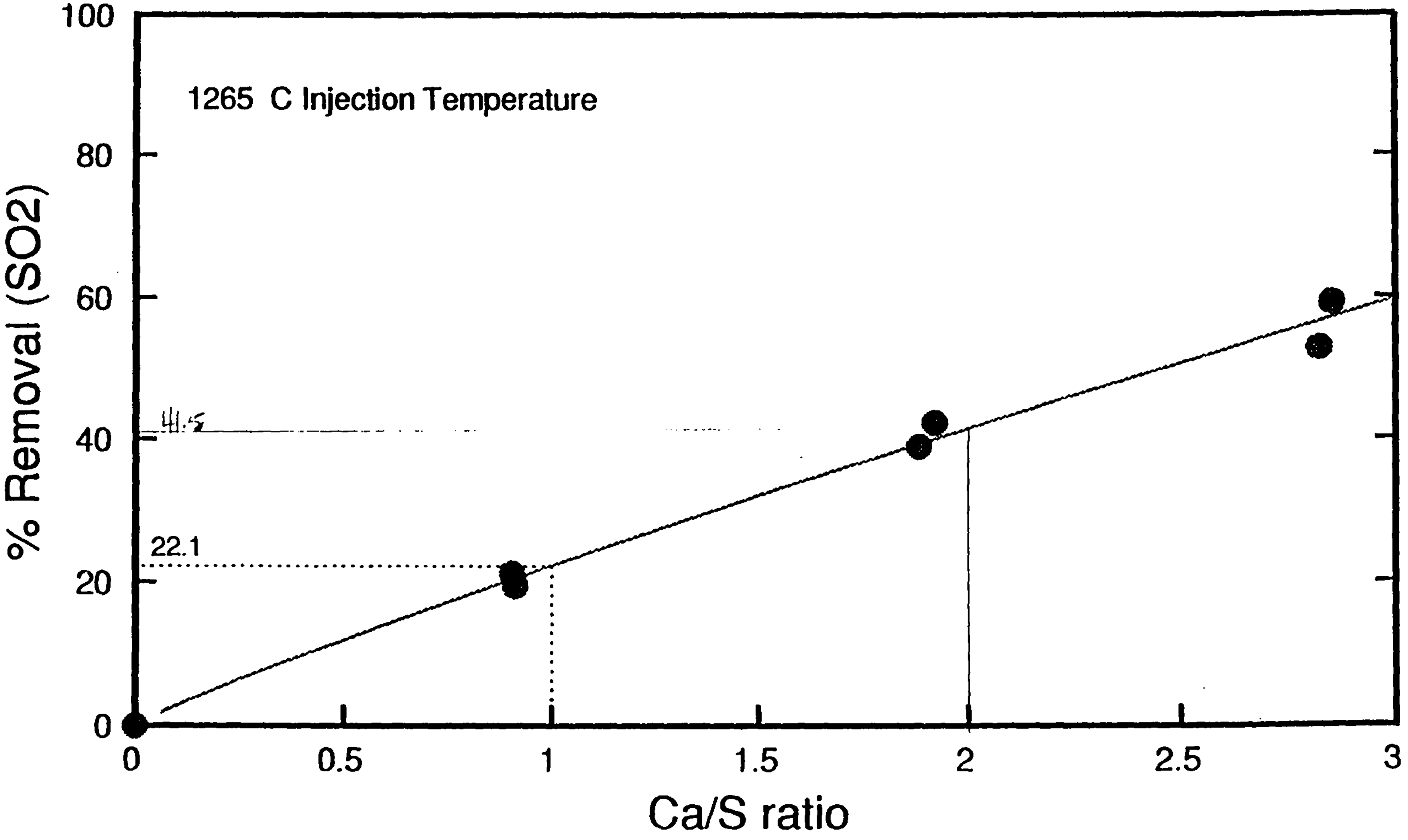
Dry Injection of as received CaCO3 at Port 4U



4/09/91
NFT0409A.DRW
N44

Nalco Fueltech Test Results

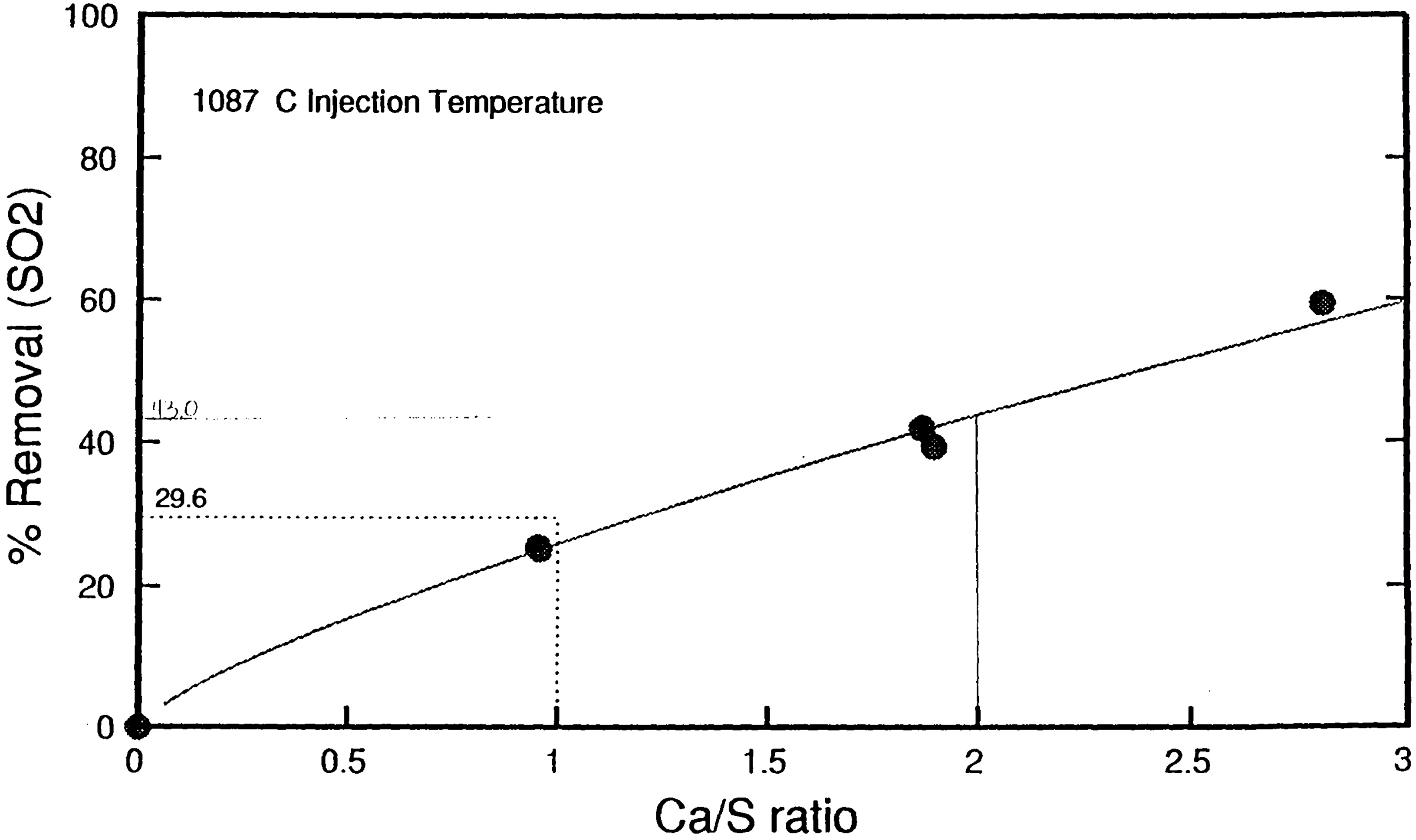
Dry Injection of as received CaCO3 at 3M



4/12/91
NFT0412A.DRW
N46

Nalco Fueltech Test Results

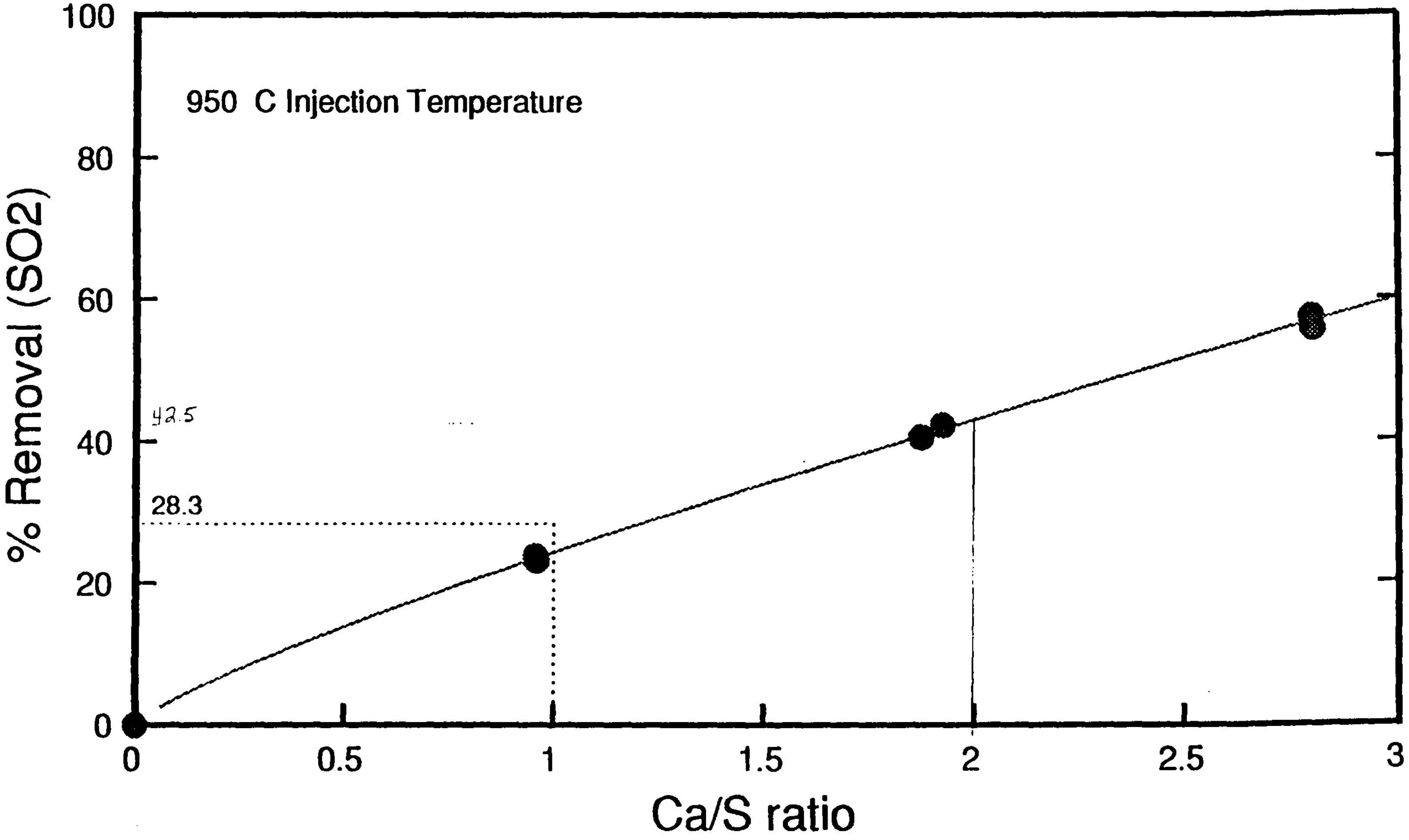
Dry Injection of as received CaCO3 at 4L



4/15/91
NFT0415.DRW
N47

Nalco Fueltech Test Results

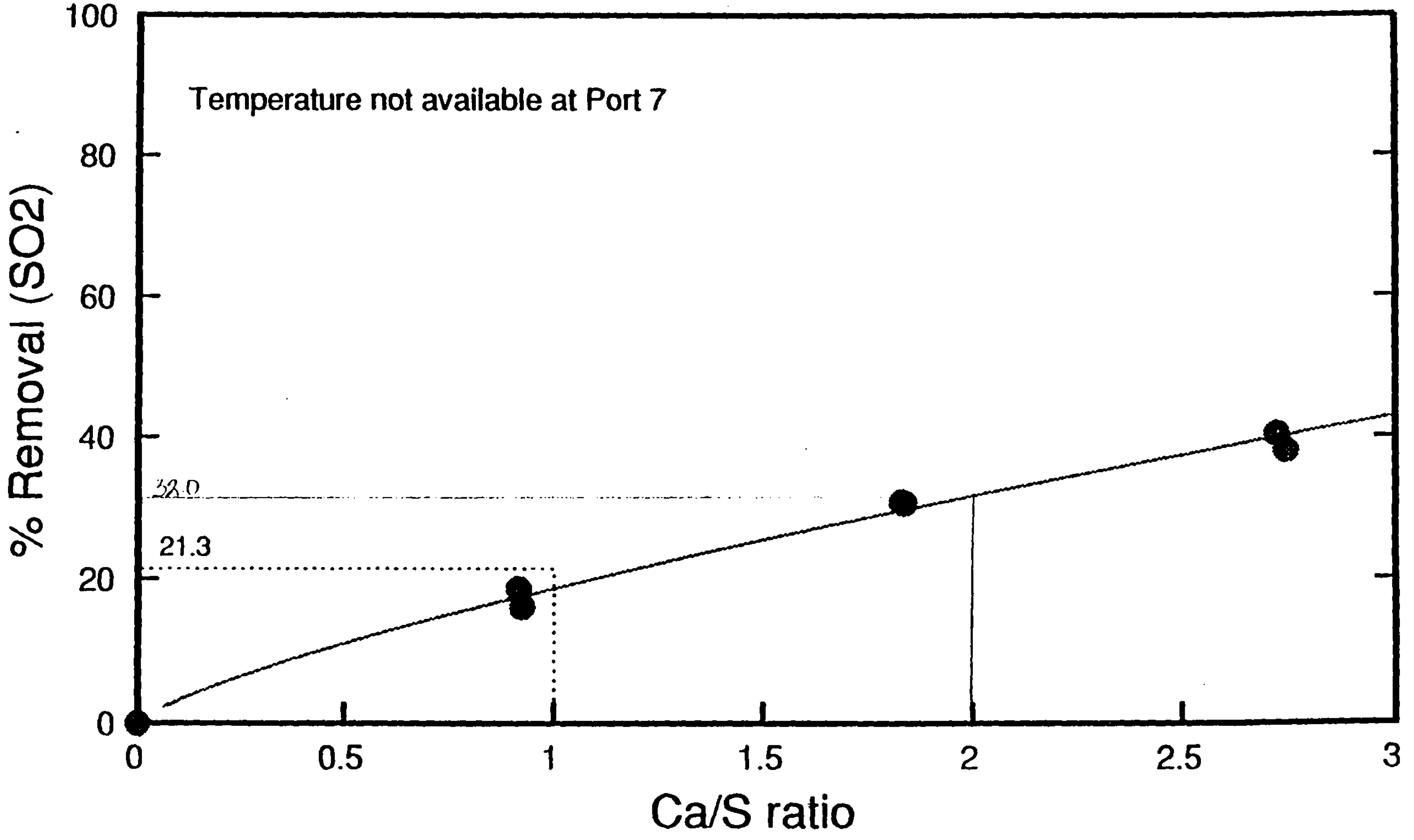
Dry Injection of as received CaCO3 at Port 6



4/16/91
NFT0416.DRW
N48

Nalco Fueltech Test Results

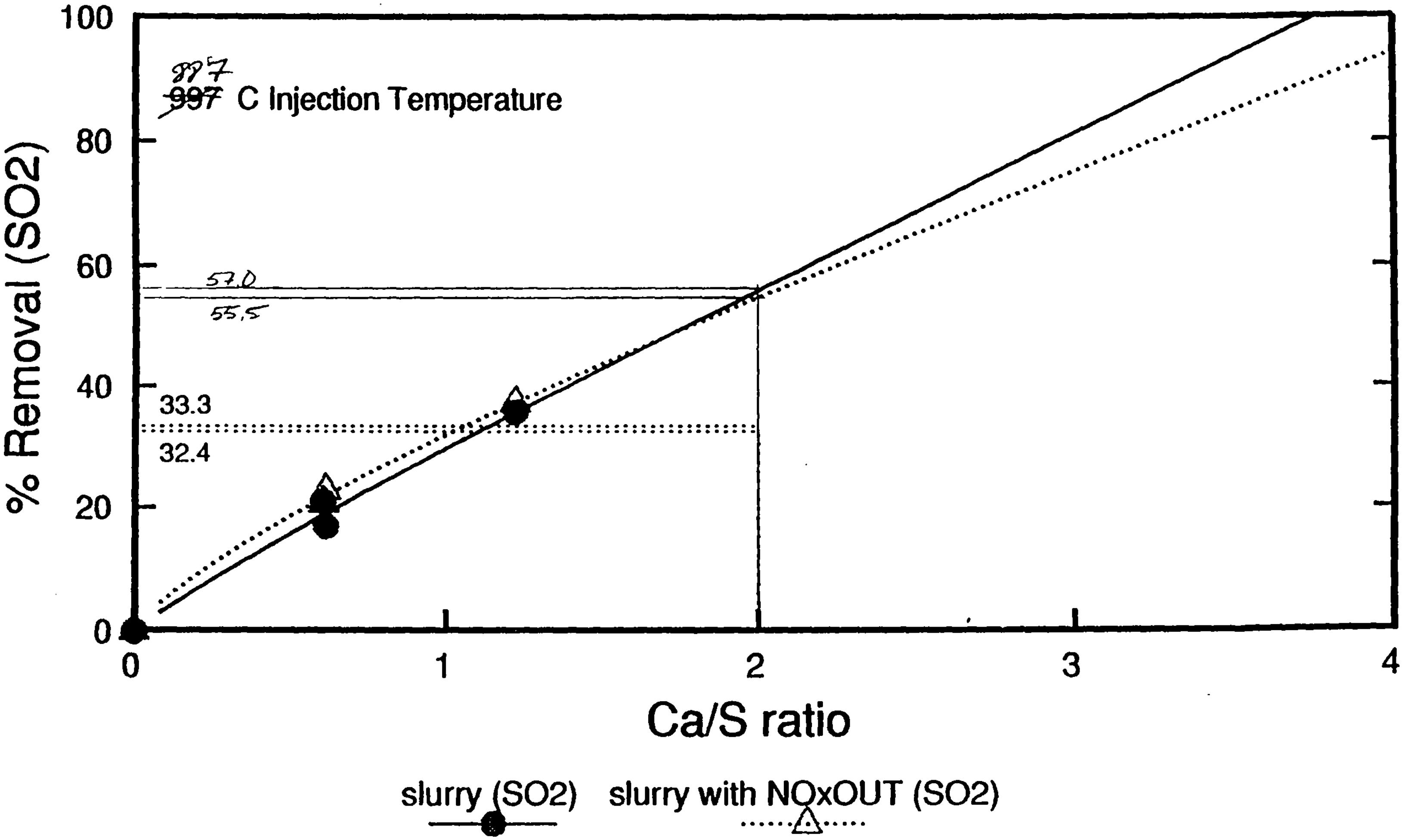
Dry Injection of as received CaCO3 at Port 7



4/16/91
NFT0416A.DRW
N49

Nalco Fueltech Test Results

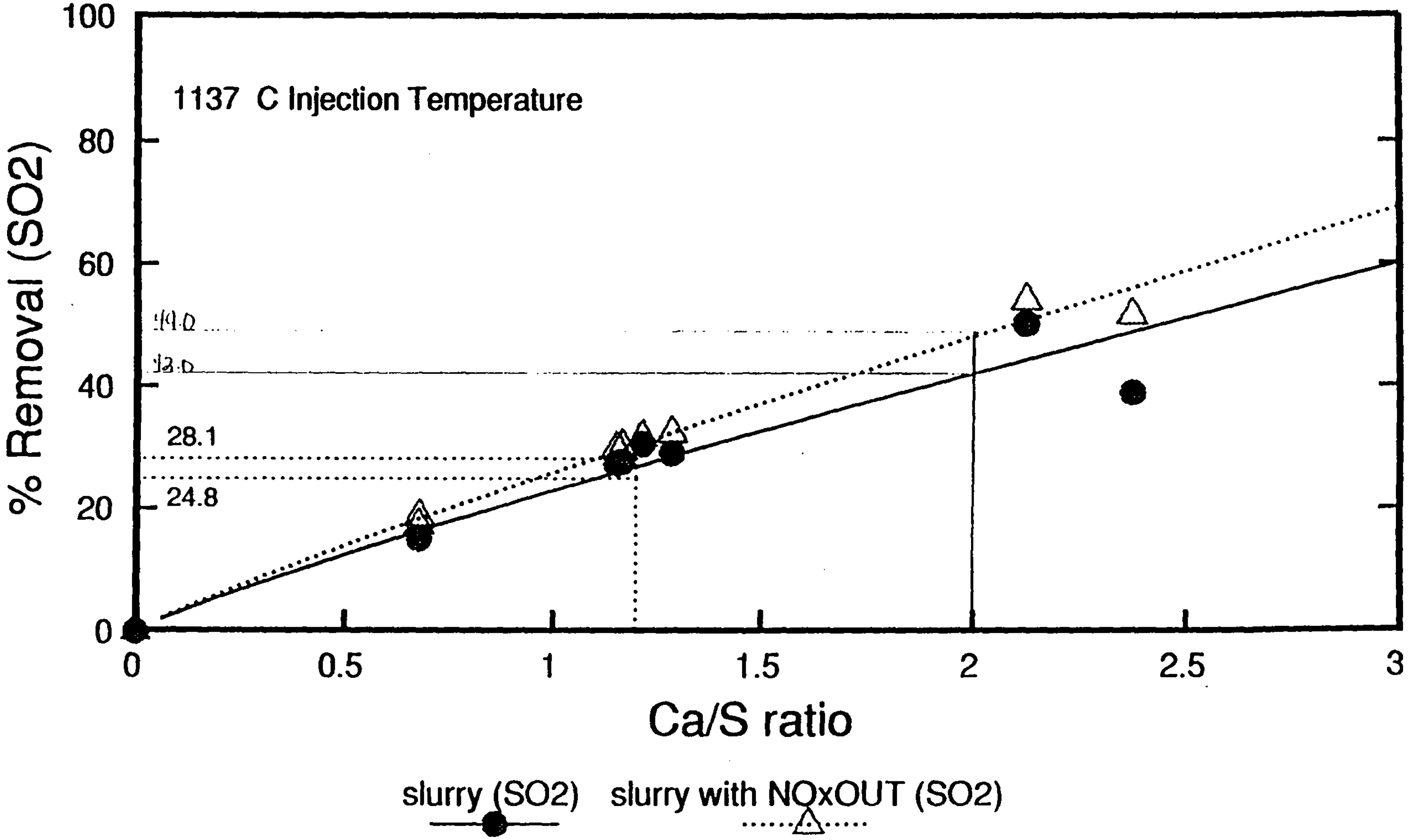
CaCO3 slurry injection at 4L



4/18/91 and 4/19/91
NFT0418A.DRW
N51 & N52

Nalco Fueltech Test Results

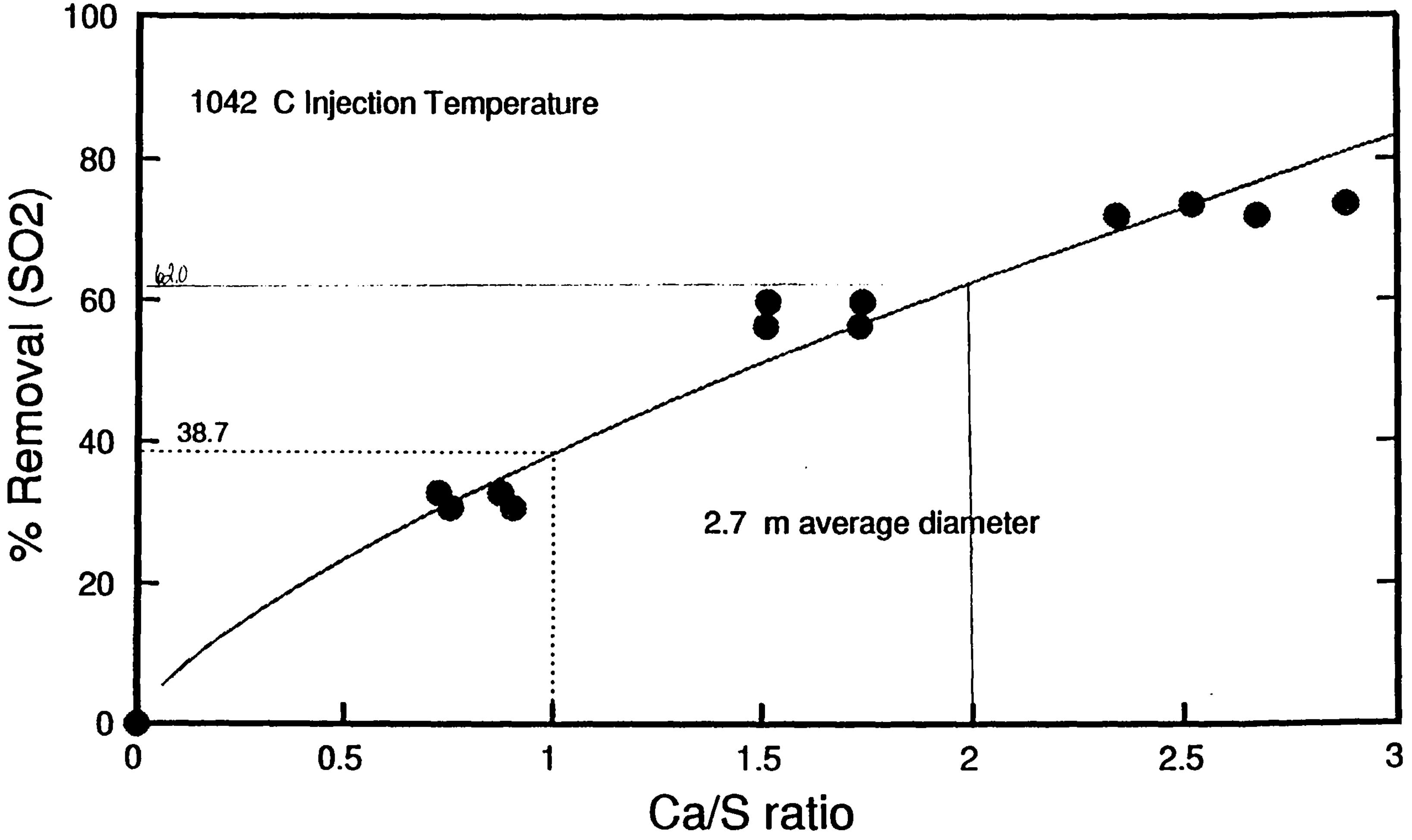
CaCO3 slurry injection at 3R



4/22/91 and 4/23/91
NFT0423A.DRW
N53 & N54

Nalco Fueltech Test Results

Dry Injection of CaCO3; <10 Micrometers (Port 5)

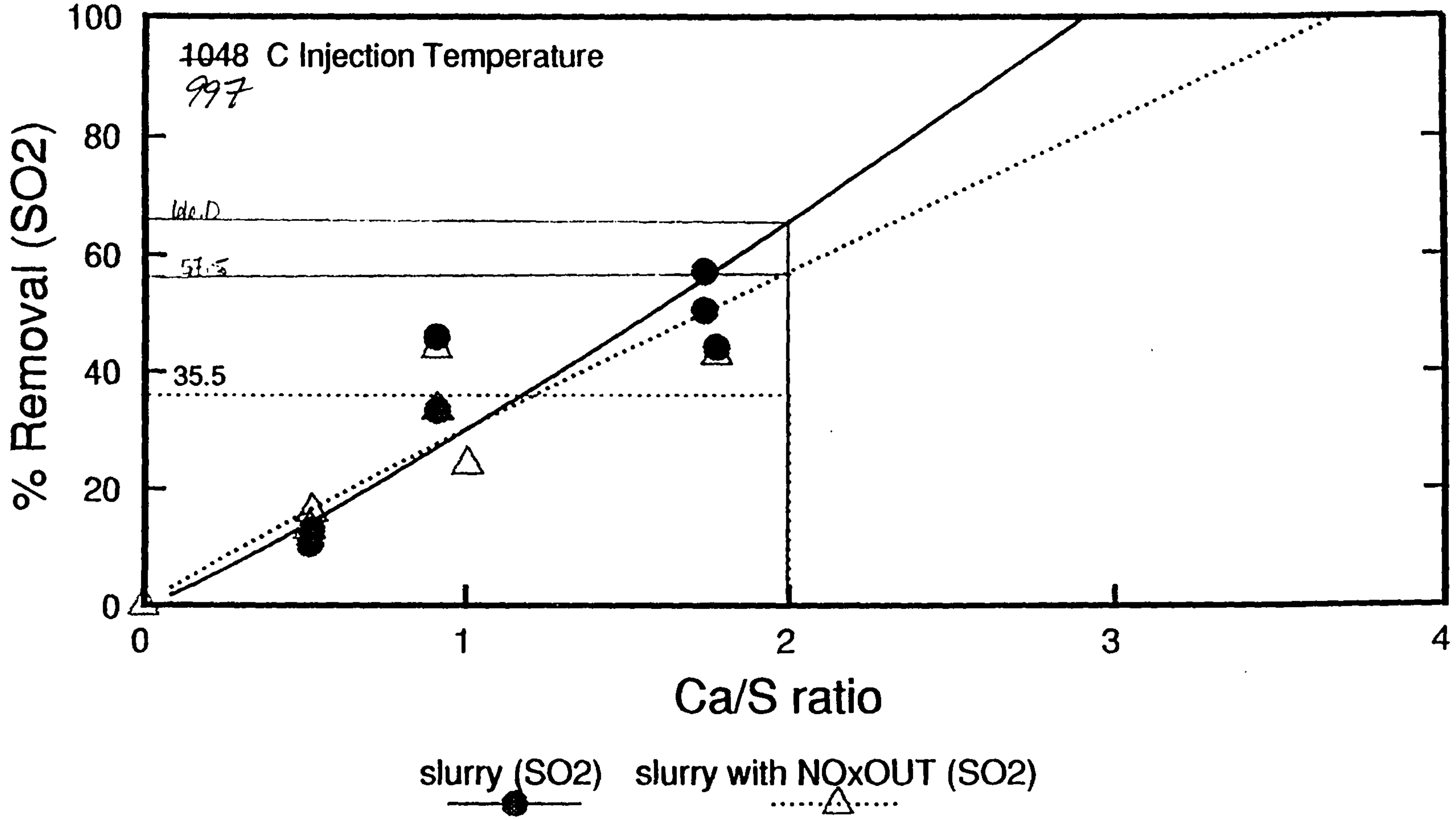


4/25/91
NFT0425A.DRW
N55

Nalco Fueltech Test Results

CaCO3 slurry injection at 4U

2.7 m average diameter CaCO3

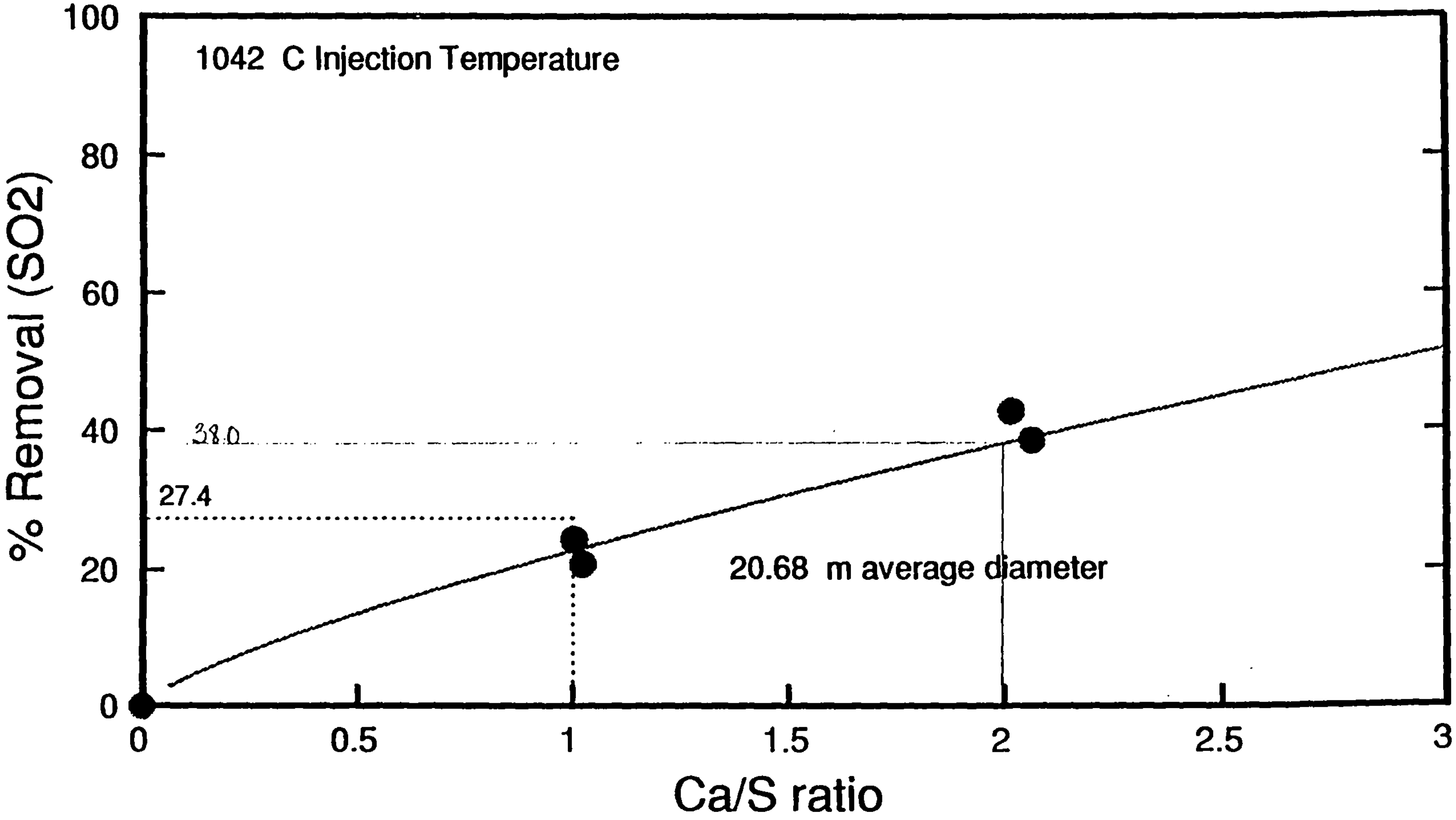


4/26/9
NFT0426.DRW
N56 & N57

Nalco Fueltech Test Results

Dry Injection of CaCO3 Port 5

75 > CaCO3 > 25 m

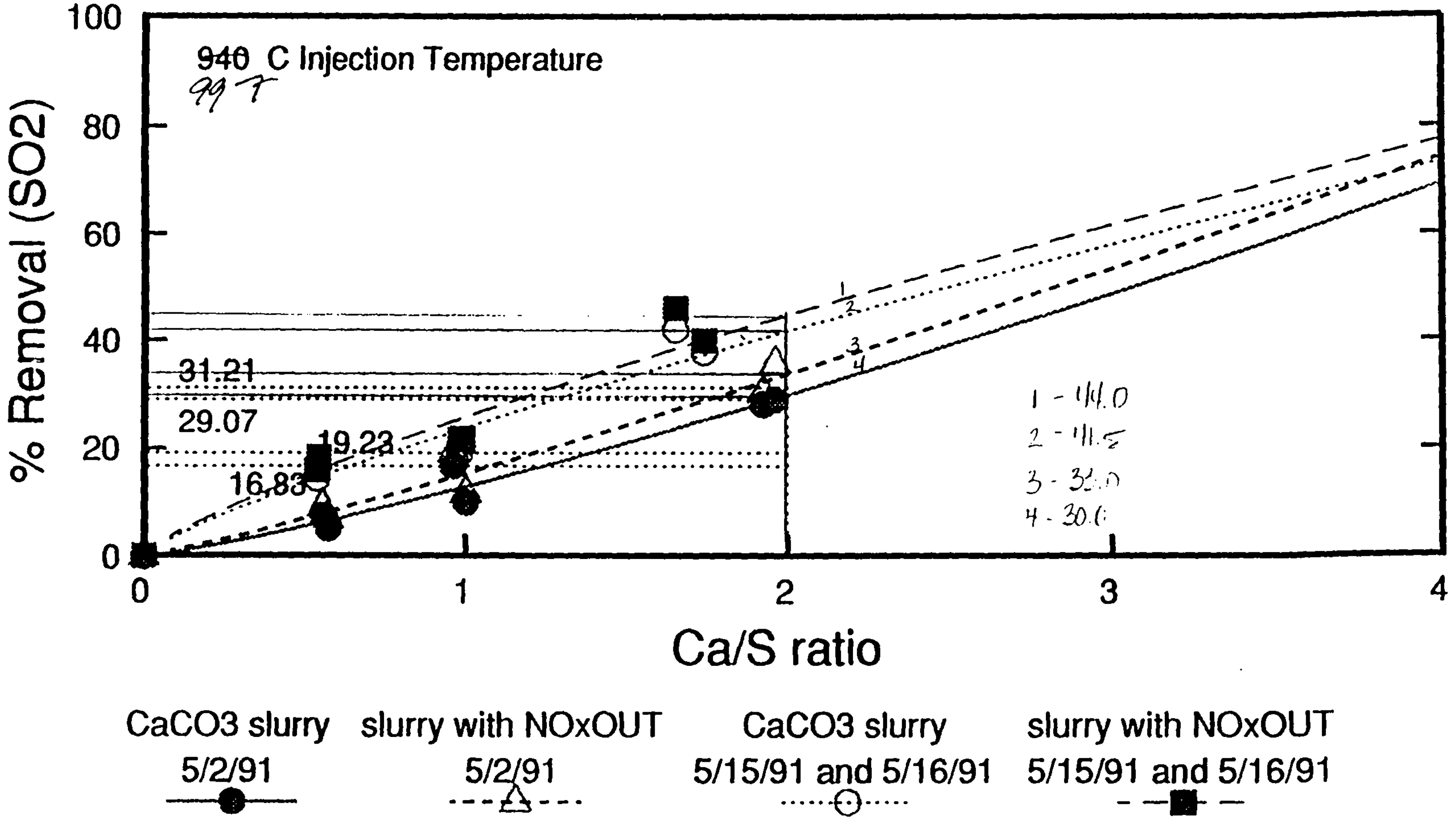


4/29/91
NFT0429.DRW
N58

Nalco Fueltech Test Results

Slurry Injection of CaCO3 at Port 4U

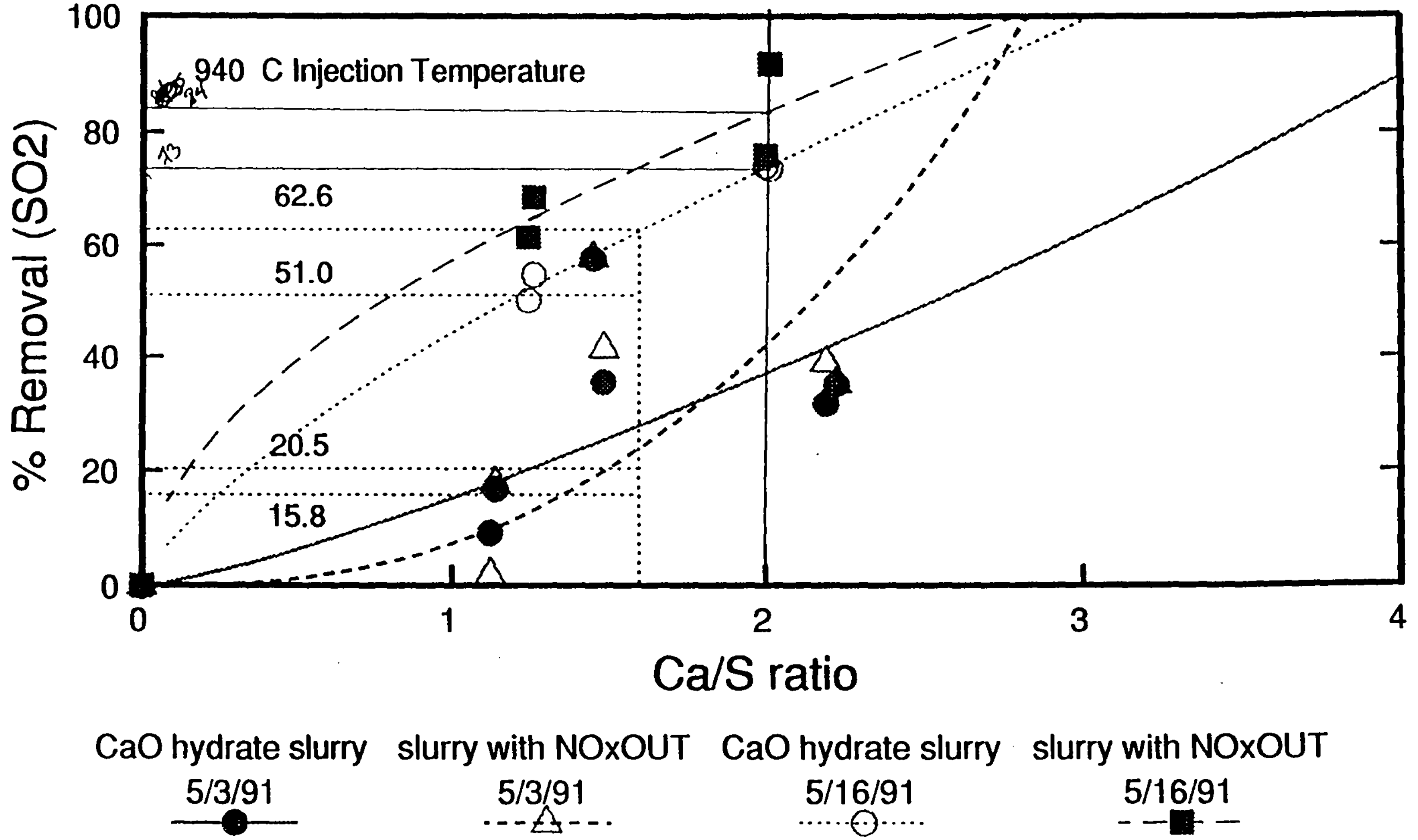
20.68 m ave diameter



5/3/91, 5/15/91 and 5/16/91 (re-test)
NFT0502.DRW
N59 & N63

Nalco Fueltech Test Results

Slurry Injection of Hydrated CaO



5/3/91 and 5/16/91 (re-test)
NFT0503A.DRW
N60 & N64

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(Please read Instructions on the reverse before complet

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15\. SUPPLEMENTARY NOTES AEERL project officer is Brian K. Gullett, Mail Drop 4, 919/541-1534.

16. ABSTRACT The report gives results of work concentrating on characterizing three process operational parameters of a technology that combines sorbent injection and selective non-catalytic reduction for simultaneous sulfur dioxide/nitrogen oxide (SO2/NCx) removal from coal-fired industrial boilers: injection temperature, sorbent type and reductant/pollutant stoichiometric ratio. A slurry composed of a urea-based (NOxOUT A or NOxOUT A+) and various calcium-based sorbents was injected at a range of temperatures and reactant/pollutant stoichiometries into a natural-gas-firec pilot-scale reactor with doped pollutants. Up to 80% reduction of SO2 and NOx at reactant/pollutant stoichiometric ratios of 2 and 1.5, respectively, was achieved. SO2 emission reductions from slurry injection were enhanced moderately when compared with dry sorbent injection methods, possibly caused by sorbent fracturing to smaller, more reactive particles. Emissions from ammonia (NH3) slip (unreacted nitrogen-based reducing agent) and nitrous oxide (N2O) formation were reduced in comparison with other published results, while similar NOx reductions were obtainec Increased carbon monoxide (CO) emissions, caused by the decomposition of urea, were moderate. The results of this pilot-scale study have shown high reduction of both SO2 and NOx.

17\. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Sorbents	Pollution Control	13B	11G
Nitrogen Oxides	Catalysis	Stationary Sources	07B	07D
Sulfur Dioxide	Urea	Sorbent Injection		07C
Boilers	Slurries	Selective Non-catalytic	13A	
Coal	Calcium	Reduction (SNCR)	21D	
Combustion	Ammonia		21B	

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