Cardinal 1 Selective Non-Catalytic Reduction (SNCR) Demonstration Test Program

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Final Report, July 2000

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REPORT SUMMARY

Selective Non-Catalytic Reduction (SNCR) is a potential supplement or alternative to Selective Catalytic Reduction (SCR) for NO_x control in fossil power plants. This demonstration addressed the outstanding issues of scaleup and balance-of-plant impacts of SNCR operation with high-sulfur coal.

Background

NO_x reductions in the range of 30-50% on relatively small boilers have been demonstrated using urea-based SNCR technology. However, at the time this demonstration took place, there had been no long-term operating experience with furnaces larger than approximately 160 MW. In addition, virtually all applications firing medium- and high-sulfur coal had experienced troublesome impacts downstream of the reagent injection location, primarily involving air preheater (APH) pluggage with ammonium bisulfate (ABS).

Objective

To conduct a demonstration designed to address the issues of scaleup and balance-of-plant impacts of SNCR applications in boilers firing high-sulfur coal.

Approach

In early 1996 EPRI began the search for a site for this potentially high-risk demonstration, with the specific requirements that the unit be larger than 500 MW and fire coal with a sulfur content greater than 2.5%. In mid-1997 American Electric Power (AEP) agreed to proceed with the tests on their Cardinal Unit 1, a 600-MW cell-fired boiler, retrofit with low-NO_x burners and firing a nominal 3.8% sulfur coal. The Ohio Coal Development Office, the U.S. Department of Energy, the vendor Fuel Tech, Inc., and fifteen EPRI members, including major support from AEP, provided additional funding. The technical goal of the project was to demonstrate 30% NO_x reduction with less than 5-ppm ammonia slip without adverse balance-of-plant impacts. The project team planned a two-phased test program, with Phase I optimization tests to be used to define operating parameters for the long-term demonstration in Phase II.

Results

The optimization tests determined that NO_x reductions of up to 32% at full load and 38% at lower loads could be achieved while maintaining ammonia slip less than 5 ppm. Using the results from the these tests, the SNCR system was run in an automatic mode under normal load dispatch conditions for a nominal six-week period for the Phase II demonstration. During this time, the SNCR system maintained a NO_x level of 0.51 lb/MMBtu at full load and 0.39 lb/MMBtu at the minimum load of 350 MW, corresponding to NO_x reductions of approximately 25% at full load and 30% at low load. Lower baseline NO_x during the long-term demonstration resulted in lower

percentage NO_x reductions than in the optimization tests, because the SNCR control system is designed to meet a given NO_x emission, not a percentage reduction. During the long-term demonstration, ABS deposition caused the full-load APH pressure drop to increase from 4.4 to 5.7 inches H_2O. While this increase is modest, the impact of longer-term operation is not known. After completion of the long-term demonstration, the APH pressure drop decreased back to the baseline value after three weeks of operation without urea injection.

EPRI Perspective

This demonstration continues a long history of EPRI involvement in urea-based SNCR, for which EPRI developed the original 1980 patent. As a result of this work, it was concluded that for some large-scale coal-fired boilers, SNCR may be a candidate technology for NO_x reductions in the range of 30%. However, if medium- to high-sulfur coal is fired, the necessity for periodic off-line water washings should be taken into account. SNCR remains a niche technology that can be used either separately or in conjunction with other NO_x reduction approaches.

Related EPRI publications include the State-of-the-Art Assessment of SNCR Technology (EPRI report TR-102414) and SNCR Feasibility and Economic Evaluation Guidelines for Fossil-Fired Utility Boilers (TR-103885), along with site demonstrations at LILCO's Port Jefferson Unit 3 (TR-104910), Atlantic Electric's B.L. England Unit 1 (TR-105068), and PSE&G's Mercer Unit 2 (TR-105071). Combinations of SNCR with other NO_x control technologies have been addressed in Achieving NO_x Compliance at Least Cost: A Guideline for Selecting the Optimum Combination of NO_x Controls for Coal-Fired Boilers (TR-111262) and UMBRELLA Software for Assessing NO_x Control Technology Combinations (CM-113807).

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Keywords

Selective non-catalytic reduction (SNCR)
NO_x reduction

ABBREVIATIONS AND ACRONYMS

AEP	American Electric Power
CAA	Clean Air Act
CEM	Continuous Emissions Monitor
CCS	Controlled Condensation System
CO	Carbon Monoxide
CO_2	Carbon Dioxide
EPRI	Electric Power Research Institute
ESP	Electrostatic Precipitators
FERCo	Fossil Energy Research Corp.
FGR	Flue Gas Recirculation
ft^3	Cubic feet
H_2O	Water
H_2SO_4	Sulfuric Acid
lb	Pounds
lb/MMBtu	Pounds per Million Btu
LNB	Low-NO_x Burner
MNL	Multi-Nozzle Lance
MW	Megawatt
NEO	Norsk Electro Optikk
$(NH_2)_2CO$	Urea
NH_3	Ammonia
$(NH_4)_2SO_4$	Ammonium Sulfate
NH_4HSO_4	Ammonium Bisulfate
NO	Nitric Oxide
NO_x	Oxides of Nitrogen
NO_2	Nitrogen Oxide
N_2O	Nitrous Oxide
NSR	Normalized Stoichiometric Ratio
O_2	Oxygen
OFA	Overfire Air
PLC	Programmable Logic Controller
ppm	parts per million
ppm_c	parts per million, corrected to 3% O_2
S	Sulfur
scfh	Standard Cubic Feet Per Hour
SCR	Selective Catalytic Reduction
SNCR	Selective Non-Catalytic Reduction
SO_2	Sulfur Dioxide
SO_3	Sulfur Trioxide

EXECUTIVE SUMMARY

Background and Objectives

A demonstration of urea-based Selective Non-Catalytic Reduction (SNCR) for NO_x control was conducted on AEP's Cardinal Unit 1, a 600-MW cell-fired boiler retrofitted with low-NOx burners that fires a nominal 3.8% S coal. The project was the first application of urea-based SNCR to a large utility boiler burning high-sulfur coal. The demonstration was funded by EPRI, AEP, a consortium of EPRI member utilities, the Ohio Coal Development Office, the U.S. Department of Energy and Fuel Tech, Inc.

SNCR is a post-combustion NO_x control process developed to reduce NO_x emissions from fossil-fuel combustion systems. SNCR processes involve the injection of a chemical containing nitrogen into the combustion products, where the temperature is in the range of 1600°F – 2200°F (870°C – 1205°C). In this temperature range, the chemical reacts selectively with NO_x in the presence of oxygen, forming primarily nitrogen and water. Although a number of chemicals have been investigated and implemented for SNCR NO_x reduction, urea and ammonia have been most widely used for full-scale applications.

The test program was divided into two phases. Following construction and startup of the SNCR system, the first phase of testing – system optimization – determined the SNCR parameters to be used during automatic operation. Once the optimization tests were completed, the SNCR parameters to be used over the load range were selected and programmed into PLC. The second phase of testing consisted of automatic operation of the SNCR system while the boiler was under normal load dispatch. This long-term demonstration, which lasted approximately six weeks, demonstrated the achievable day-to-day NO_x reductions and documented balance-of-plant impacts, including air preheater deposition and NH_3 absorption on ash.

SNCR System

The SNCR system consists of 1) the urea storage area; 2) the urea pumping, dilution and distribution area; and 3) three separate injection levels. All of these were designed, fabricated, installed, and optimized by Fuel Tech, Inc.

The injection system comprises three separate zones, or levels:

- Zone 1: 23 wall injectors — Located on all four sides approximately 25 feet below the nose
- Zone 2: 13 wall injectors — Located on the front and side walls at about the elevation of the nose
- Zone 3: 3 levels of retractable Multi-Nozzle Lances (MNLs) — Located above the nose at the exit of the wing walls

The urea flow and dilution water flow to each zone can be varied independently. This can be done automatically over the load range. In addition, the diluted urea solution can be manually biased to each injector in Zones 1 and 2. Each MNL has three liquid circuits that allow the urea solution to be manually biased along the lance.

Optimization Tests

The goal of the test program was to complete the optimization of a commercial SNCR installation. The optimization testing began on March 15 and was completed April 27, 1999.

Systematic procedures were followed during the optimization tests. At the start of each day, a baseline test was performed once the unit was operating under steady-state conditions at the desired test load. Following the baseline test, the SNCR system was turned on, and a test conducted. Depending on the steadiness of unit operation, additional baseline tests were performed between the SNCR tests. A baseline test was also performed at the end of each day. These baseline data were used to determine NO_x reductions for each SNCR test condition.

The optimization tests were performed at three primary loads: 600 MW, 450 MW and 350 MW. Limited numbers of tests were also performed at 530 MW and 410 MW.

As a result of the optimization tests, the following performance was documented for NH_3 slip levels less than 5 ppm:

600 MW: up to 32% NOx reduction
450 MW: up to 38% NOx reduction
350 MW: up to 38% NOx reduction

At full load the optimum performance was achieved with Zones 2 and 3. At intermediate load the optimum performance was found with Zones 1, 2 and 3, while Zones 1 and 2 provided the optimum performance for the low-load condition.

Long-term Tests

The goal of the long-term portion of the test program was to document the performance of the SNCR system during automatic operation, while the boiler was under normal load dispatch, and to identify any balance-of-plant impacts.

With the SNCR system in automatic operation a baseline NO_x level is not available, so controlling to a given percentage NO_x reduction is not possible. Rather, the SNCR control scheme uses a prescribed set of SNCR parameters versus load in a feed-forward manner to achieve a target outlet NO_x level. These settings are based on the results of the optimization tests. Trim signals can then be used to modify the feed-forward controls (e.g., furnace temperature measurements or CEM NO_x vs. target NO_x). As a consequence, the NO_x reduction can only be calculated after the fact using NO_x levels measured either before the SNCR system is put in automatic operation or after the system is turned off.

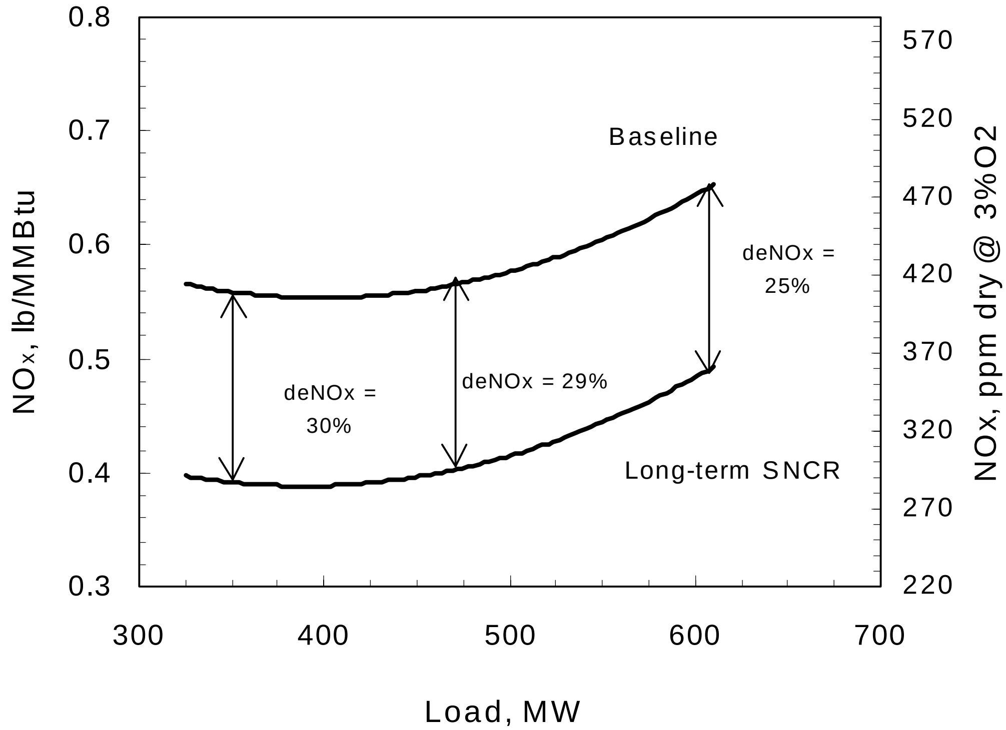
Based on the data from the optimization tests, Fuel Tech selected SNCR parameters that would achieve NO_x levels of 0.49 lb/MMBtu at full load and 0.36 lb/MMBtu at reduced loads. The full-load target represents a 30% reduction from an assumed baseline NO_x level of 0.70 lb/MMBtu. The lower-load target represents a 36% reduction from an assumed baseline of 0.56 lb/MMBtu.

The long-term testing began on September 27 and continued through November 19, 1999. This period comprised about 1270 hours. The SNCR system was on line for about 960 hours of this time. Most of the downtime can be attributed to a period of nominally 240 hours when the boiler was off line. About 241,000 gallons of urea were used during this long-term test period.

Figure ES-1 shows NO_x emissions plotted versus load for the baseline and long-term SNCR test periods. These are curve fits to the CEM data, which can be found in Figure 5-7 of the report. Average NO_x reductions varied from 25 percent at full load to 30 percent at 350 MW for the long-term testing, compared to average reductions of 32 percent at full load and 38 percent at 350 MW during the optimization testing. The lower NO_x reductions at full load were the result of lower baseline NO_x levels. Since the SNCR control system controls to a target exit NO_x level, a lower baseline NOx meant operating at a lower percentage NO_x reduction to achieve the target outlet NO_x level.

Periodic wet chemical NH_3 measurements were made during the long-term tests. Measured ammonia emissions were generally below 5 ppm. Off-design conditions occasionally resulted in concentrations greater than 5 ppm.

During the long-term tests, ash samples were obtained from the hoppers of the electrostatic precipitator (ESP). The ash ammonia content averaged 150 ppm (weight basis).

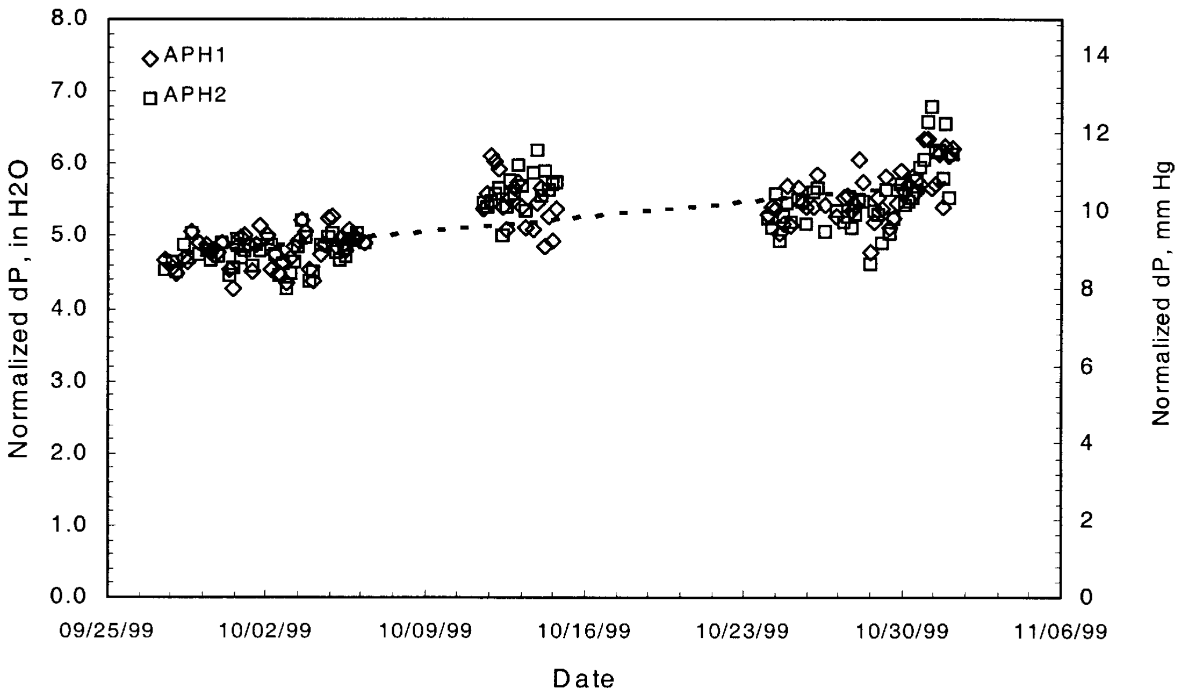


ES-1
Curve Fits of the Baseline and Long-term CEM NO_x Emissions Data

Near the end of the long-term testing, a series of ammonia tests was performed on Cardinal Unit 1 at three locations to determine the fate of ammonia slip through the unit. These sample locations included the economizer exit, APH exit and ESP exit. Over 90% of the ammonia present at the economizer exit was retained in either the air preheater or ESP, with less than 10% exiting the stack.

Air Preheater Pressure Differential

The air preheater (APH) pressure differential was monitored during the long-term testing using plant instrumentation. Figure ES-2 shows the APH pressure differential as a function of time, using data collected at all loads and then normalized to full-load conditions. As can be seen in the figure, the APH pressure differential increased with time during the long-term tests. These pressure drops continued to be monitored following the completion of the long-term testing. After about three weeks of operation with the urea turned off, the pressure differentials were essentially back to the levels recorded at the start of the long-term testing.



ES-2
APH Pressure-Drop History, Normalized to 600 MW

Economics

The installed cost for the SNCR system of $6.5 million, including $3.5 million in capital costs and $3.0 million for installation, is equivalent to $10.8/kW. Of these costs, $600,000, or $1.0/kW, were attributed to costs associated with retrofitting to a pressurized unit.

The chemical costs were $377/hour at full load for the long-term testing, based on a reagent cost of $0.72 per gallon.

The primary boiler efficiency penalty for the Cardinal Unit 1 SNCR system is the energy loss associated with evaporating the urea solution. When the solution is injected into the flue gas, some energy that would ordinarily be transferred to the steam is used to evaporate the solution. This loss is partially offset by the energy released as the urea reacts. The boiler efficiency penalty associated with vaporization for the three loads during the long-term tests varied from 0.2% at 350 MW to 0.5% at full load.

Conclusions

The following major conclusions can be drawn based on the results of this test program:

- During the long-term demonstration, the SNCR system achieved its stated performance goals of 30 percent NO_x reduction with less than 5 ppm NH_3 at loads of 450 MW and lower. SNCR performance at the three primary test loads were as follows:

Load, MW	NO_x Reduction %	NH_3 Slip, ppm
600	25	4
450	29	2
350	30	3

  The lower NO_x reduction at full load (600 MW) was the consequence of lower full-load baseline NO_x levels than those experienced during the optimization tests.

- The SNCR system operated as desired for the duration of the long-term demonstration with no operating problems which precluded the system from achieving the desired performance.
- The 960 hours of long-term demonstration resulted in an increase in air preheater pressure differential of about 1.3 inches H_2O (2.4 mm Hg) from 4.4 to 5.7 inches H_2O (8.2 to 10.6 mm Hg). A longer test period would be needed to determine when the unit would have to shut down to wash the air preheater.
- Air preheater pressure differential was monitored after completion of the long-term SNCR demonstration. The pressure differential was found to have decreased back to the pretest levels after about three weeks of operation, apparently as a result of self-cleaning, since the air preheater was not washed.
- Ash samples taken from hoppers in the first ESP field showed NH_3 concentrations between nominally 100 and 200 ppm. Ash NH_3 concentration was about 90% lower in samples taken from the second ESP field hoppers.
- As the gases pass through the unit from the economizer to the stack, over 90 percent of the ammonia initially present is removed in either the APH or ESP before exiting the stack.

ABSTRACT

A demonstration of urea-based Selective Non-Catalytic Reduction (SNCR) of NO_x was conducted on American Electric Power's (AEP's) Cardinal Unit 1, a 600-MW cell-fired boiler retrofitted with low-NOx burners that fires a nominal 3.8%-sulfur coal. This demonstration represents one of the largest boilers firing high-sulfur coal to which SNCR has been applied. The technical goal of the project was to demonstrate 30% NO_x reduction with less than 5-ppm ammonia slip without adverse balance-of-plant impacts.

Following construction of the SNCR system by Fuel Tech, Inc., and AEP, a two-phase test program was conducted. Phase I involved optimization tests to define operating parameters to be used during a long-term Phase II test period. The optimization tests determined that NO_x reductions at full load of up to 32% could be achieved while maintaining NH_3 slip less than 5 ppm. At lower loads, NO_x reductions increased to 38% with less than 5-ppm NH_3 slip.

Using the results from the optimization tests, the SNCR system was run in an automatic mode under normal load dispatch conditions for a nominal six-week period. During this time, the SNCR system maintained a NO_x level of 0.51 lb/MMBtu at full load and 0.39 lb/MMBtu at the minimum load of 350 MW, corresponding to NO_x reductions of about 25% at full load and 30% at low load.

During the long-term demonstration, some deposition occurred in the air preheaters, increasing the full-load pressure drop from 4.4 to 5.7 inches H_2O. While this increase in air preheater pressure drop is modest, the impact of longer-term operation is not known. After completion of the long-term demonstration, the air preheater pressure drop decreased back to the baseline value after three weeks of operation without urea injection.

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INTRODUCTION

Background

Air quality agencies at both the federal and local levels throughout the Unites States are calling for a reduction in nitrogen oxide emissions from industrial and utility combustion sources, including fossil-fueled power plants.

Various technologies are available to control NO_x emissions from fossil fuel-fired power plants, including both combustion modification techniques and post-combustion techniques. Combustion modification techniques include low-NO_x burners (LNBs), overfire air (OFA), windbox flue gas recirculation (FGR) and reburning. Combustion modifications are, however, only able to provide a modest level of reductions on coal-fired units. As NO_x regulations become stricter, post-combustion techniques must be considered. These techniques include Selective Non-Catalytic Reduction (SNCR), using either urea or ammonia, and Selective Catalytic Reduction (SCR).

Cardinal Unit 1 was recently retrofit with LNBs, which reduced NO_x levels to under 0.68 lb/MMBtu, the limit dictated by Title IV of the 1990 CAA Amendments for cell-fired boilers. Subsequent to the LNB retrofit, AEP decided to evaluate SNCR in conjunction with the LNBs. This commercial demonstration of a urea-based SNCR system was conducted at Cardinal Unit 1, a 600-MW pulverized-coal-fired boiler, firing a high-sulfur (nominally 3.8%) coal. The project was significant, as it was the first application of urea-based SNCR on a large utility boiler burning high-sulfur coal. The project was funded by EPRI, AEP, a consortium of EPRI member utilities, the Ohio Coal Development Office, the U.S. Department of Energy and Fuel Tech, Inc.

SNCR Process Description

SNCR is a post-combustion NO_x control process developed to reduce NO_x emissions from fossil-fuel combustion systems. SNCR processes involve the injection of a chemical containing nitrogen into the combustion products, where the temperature is in the range of 1600°F – 2200°F (870°C – 1205°C). In this temperature range, the chemical reacts selectively with NO_x in the presence of oxygen, forming primarily nitrogen and water. Although a number of chemicals have been investigated and implemented for SNCR NO_x reduction, urea and ammonia have been most widely used for full-scale applications.

For urea, it is postulated that urea $(NH_2)_2CO$ decomposes as shown below when injected:

$(NH_2)_2CO$	$\rightarrow$	$NH_3 + HNCO$	**Equation 1**

The NO_x reduction reactions then proceed as follows:

$NH_3 + OH$	$\rightarrow$	$NH_2 + H_2O$	**Equation 2**
$NHCO + H$	$\rightarrow$	$NH_2 + CO$	**Equation 3**
$NHCO + OH$	$\rightarrow$	$NCO + H_2O$	**Equation 4**
$NH_2 + NO$	$\rightarrow$	$N_2 + H_2O$	**Equation 5**
$NCO + NO$	$\rightarrow$	$N_2O + CO$	**Equation 6**

The above set of chemical reactions determines the temperature sensitivity of the SNCR process. The low-temperature part of the window is dictated by reactions 1 through 4, which form the species that react with NO. On the high-temperature side, the NH_3 begins to react with oxygen, forming additional NO, so that the process is no longer selective in terms of the reactive by-products of urea reacting with NO in the presence of O_2. As can also be seen in the reaction sequence above, Equation 6 provides a path for the formation of nitrous oxide, N_2O.

The effects of these process parameters are discussed in detail in EPRI's State of the Art Assessment: SNCR Technology (TR-102414) September 1993. [(1)]

In understanding the NO_x reduction performance potential of SNCR, it is important to recognize that its performance is not just a function of process chemistry, but also of furnace parameters. When applying SNCR to a utility boiler, the furnace essentially becomes the chemical reactor for the process. This presents challenges not encountered in systems where one has more freedom to design the chemical reactor to meet the process requirements. Although the SNCR processes superficially appear simple, implementation of these processes entails a number of challenges. These challenges arise primarily due to the relatively narrow temperature "window" over which the chemicals selectively react with NO_x.

SNCR has the capability of NO_x reductions in the range of 30-60%, depending on the specific retrofit application. Since catalysts are not involved, equipment costs are considered to be relatively low compared to other post-combustion NO_x control technologies. Although the SNCR process has many attractive features, it does have several disadvantages. One drawback is the relatively narrow temperature window (i.e., 1600°F to 2200°F; 870°C-1205°C) over which the process is effective. Another disadvantage is the possible emission, at least under some operating conditions, of undesirable by-products, such as NH_3, CO, or N_2O. Reactions between SO_3 and NH_3 resulting in air preheater deposition can be a major balance-of-plant impact. To date, it is not always possible to assess all of these issues a priori, due to the complexity of the interaction of the SNCR process and several basic boiler design features (e.g., boiler flue gas path, temperature-time history, physical access, available residence times, and gas path velocities).

Project Objectives

The overall goal of the project was to demonstrate the technical feasibility of applying the SNCR process to a large (600-MW) coal-fired utility boiler and to assess balance-of-plant impacts. The technical objective was to demonstrate an additional 30-percent NO_x reduction (above that from the LNBs) across the load range with urea-based SNCR while maintaining acceptable levels of ammonia slip and balance-of-plant impacts. AEP Cardinal Unit 1 was retrofit with Fuel Tech's urea injection system, the NO_xOUT® Process, in December 1998.

The project was structured to assess the environmental and boiler performance impacts of the SNCR process. Key issues addressed included:

- NO_x removal efficiency
- By-product emission characteristics (e.g., NH_3 slip, N_2O and CO)
- Balance-of-plant performance impacts

Project Approach

The test program was divided into two phases. Following construction and startup of the SNCR system, the first phase of testing – system optimization – determined the SNCR parameters to be used during automatic operation. This effort comprised 226 tests conducted over the period from March 15, 1999 through April 27, 1999. Once the optimization tests were completed, Fuel Tech, Inc. then programmed into the PLC the selected SNCR parameters to be used over the load range. Phase II consisted of automatic operation of the SNCR system while the boiler was under normal load dispatch. This long-term demonstration, performed for nominally six weeks, demonstrated the day-to-day NO_x reductions that were achievable, and documented balance-of-plant impacts, including air preheater deposition and NH_3 absorption on ash.

Project Participants

The optimization tests were conducted jointly by Fuel Tech and FERCo. Since this first phase was the optimization of a commercial system, rather than an R&D parametric investigation, Fuel Tech operated the SNCR system and determined the chronology of parameters to be investigated at each load. FERCo was responsible for making all of the emissions measurements and documenting the test results.

The long-term demonstration tests were conducted by FERCo, who was responsible for making daily emissions measurements, gathering and logging continuous data, and documenting test results. Fuel Tech took the lead in monitoring SNCR system performance and overseeing maintenance and repairs as needed.

AEP and EPRI spearheaded this effort to demonstrate full-scale urea-based SNCR at Cardinal Unit 1. The following EPRI members provided project cofunding:

AEP Service Corporation
Allegheny Energy
Ameren
Baltimore Gas & Electric
Buckeye Power
Cinergy
East Kentucky Power Cooperative
First Energy
GPU GENCO
Illinova
Louisville Gas & Electric Company
New England Electric System
Southern Company Services
TVA
WEPCO

Additional funding was provided from the following sources:

Fuel Tech, Inc.
Ohio Coal Development Office
U.S. Department of Energy

2
SYSTEM DESCRIPTION

2.1 Boiler

The SNCR demonstration was conducted at AEP Cardinal Unit 1. Cardinal Unit 1 is a 600-MW, opposed-fired, cell-burner boiler with five coal mills and a total of 50 individual retrofit LNBs. The front and rear walls have a symmetric firing pattern of five burners high by five burners wide, for a total of 25 burners per wall. The original burner firing pattern of each wall consisted of a single row of burners at the top of the furnace, followed by two sets of two-burner cells. A total of four sets of cell burners, two each on the front or rear walls, were installed on the boiler. Each set or row of cell burners comprised five, two-burner cells arranged across a furnace wall. Each set of five cells was fed from a single mill, for a total of ten individual burners per mill. Mill 1-2 fed the upper cells on the front wall, while Mill 1-1 fed the lower, front-wall cells. Mills 1-4 and 1-5 fed the upper and lower cells on the rear wall, respectively. Mill 1-3 still feeds the single rows of five burners located at the top of the furnace on both the front and rear walls, for a total of ten burners.

2.2 SNCR System

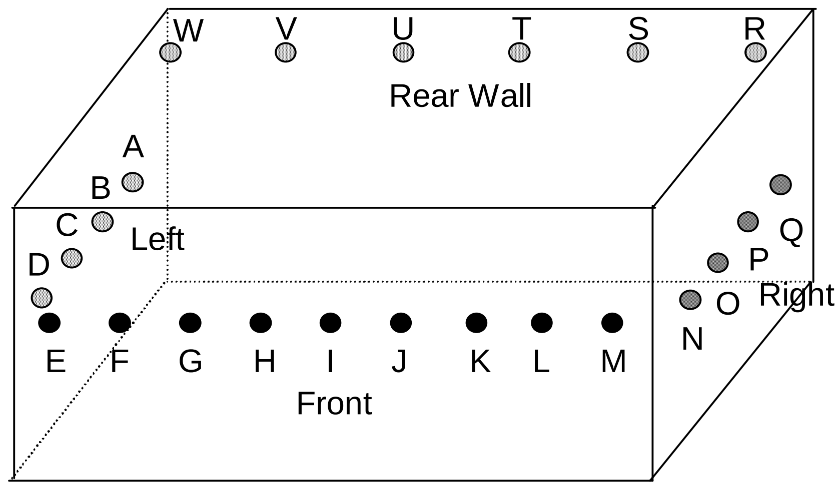
The SNCR system consists of 1) the urea storage area; 2) the urea pumping, dilution and distribution area; and 3) three separate injection levels. All of these were designed, fabricated and installed by Fuel Tech.

The urea storage facility is located on the south side of Unit 2. A room constructed on the boiler roof contains the pumping and dilution systems, metering modules for the lances and PLC. The distribution panels for the other injectors were located around the boiler at the various injection levels.

The injection system comprises three separate zones, or levels:

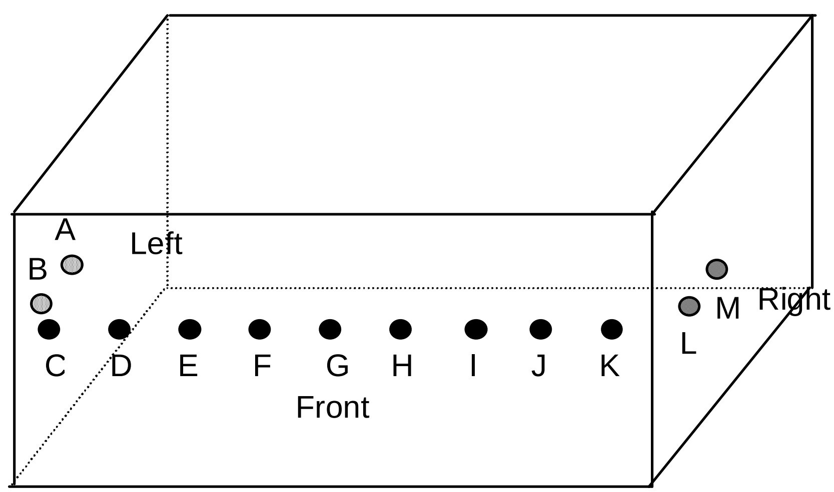
- Zone 1: 23 injectors — 9 on front wall, 4 on each side wall, 6 on rear wall (elevation 780 feet [238m] front/side walls, elevation 790 feet [241m] rear wall)
- Zone 2: 13 injectors — 9 on front wall, 2 on each side wall (elevation 807 feet [246m])
- Zone 3: 3 levels of Multi-Nozzle Lances (MNLs) — above the nose at the exit of the wing walls

Figures 2-1, 2-2 and 2-3 show the general layout of the three injection levels.



SNCR Zone 1
Injector Schematic

Figure 2-1
Injector Schematic Zone 1 (Elevation 780 feet [238m] front/sides, Elevation 790 feet [241m] rear)



SNCR Zone 2
Injector Schematic

Figure 2-2
Injector Schematic Zone 2 (Elevation 807 feet [246m])

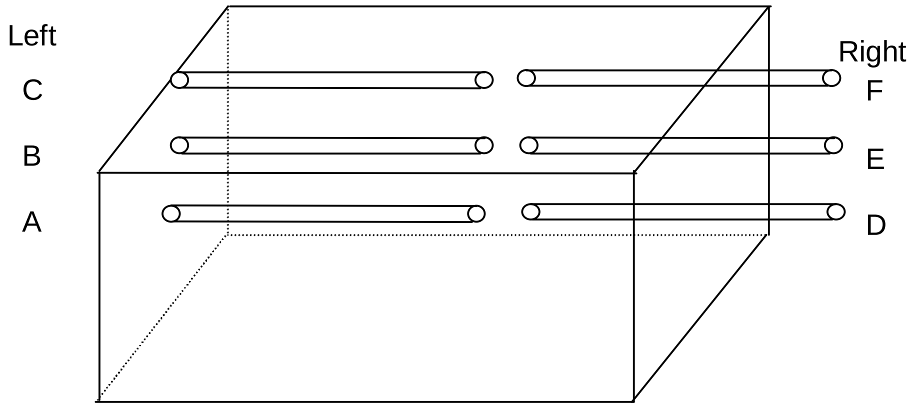


Figure 2-3
Injector Schematic Zone 3 (3 pairs of lances above the nose)

Zone 1 and Zone 2 consist of a series of wall injectors. Zone 3 consists of three pairs of retractable multi-nozzle lances (MNLs) located at the exit of the wing walls above the nose.

The urea flow and dilution water flow to each zone can be varied independently. This can be done automatically over the load range. In addition, the diluted urea solution can be manually biased to each injector in Zones 1 and 2, and automatically varied to each lance in Zone 3. Each MNL has three liquid circuits that allow the urea solution to be manually biased along the lance.

In addition to varying the solution concentration and flow rate, the atomization air pressure can also be varied at each zone. The atomization air pressure affects the droplet size of the spray.

Fuel Tech also installed two optical temperature probes, one on each side of the furnace midway between the front wall and nose at an elevation of 807 feet (246m).

The pumping, dilution and distribution of the urea solution are controlled by PLC located in the room on the boiler roof. The PLC interfaced with a personal computer via man-machine interface software.

3
TEST METHODS

During the optimization program, a number of different measurement methods were utilized:

- Continuous samples of NO, NO_x, N_2O, CO, O_2, SO_2, and CO_2
- NO, CO, and O_2 profiles
- Batch samples of NH_3 and SO_3
- Plant CEM data for NO_x, CO_2 and SO_2

During the long-term testing, the measurement methods utilized included:

- Continuous samples of NO, NO_x, N_2O, CO, O_2, SO_2 and CO_2
- Batch samples of NH_3 and ash ammonia
- Plant CEM data for NO_x and CO_2
- Continuous NH_3 measurements

These measurement methods are discussed in the following paragraphs.

3.1 Continuous Monitoring

Gaseous emissions species of NO, NO_x, N_2O, CO, O_2, SO_2, and CO_2 were measured using an extractive continuous emissions monitoring (CEM) package contained in a mobile emissions laboratory. A schematic of the sample handling system is presented in Figure 3-1. The system is comprised of three basic subsystems, including: 1) sample acquisition and conditioning system, 2) calibration gas system, and 3) analyzers. Each of these subsystems is described in the following paragraphs.

The sample acquisition and conditioning system contains components to extract a representative gas sample, transport the sample to the analyzers, and remove moisture and particulate material from the sample. In addition to performing these tasks, the system preserves the measured species and delivers them intact for analysis. For the program, the economizer exit ducts were fitted with a grid of 24 gas sample probes. The economizer exit consists of a large, horizontal center duct and two smaller ducts on each side. The gas sample grid probes were installed adjacent to the existing eight control room O_2 probes and were arranged in an eight wide by three deep array. The large center duct contained a four wide by three deep probe array, while the two smaller ducts each contained a two wide by three deep probe grid. The individual probes were connected to a flow panel with stainless steel tubing. Figure 3-2 shows the arrangement of the probe grid and the locations of the continuous NH_3 analyzers. The overall duct dimensions at this sample location are 53 feet (16.2m) wide by 19 feet (5.8m) deep.

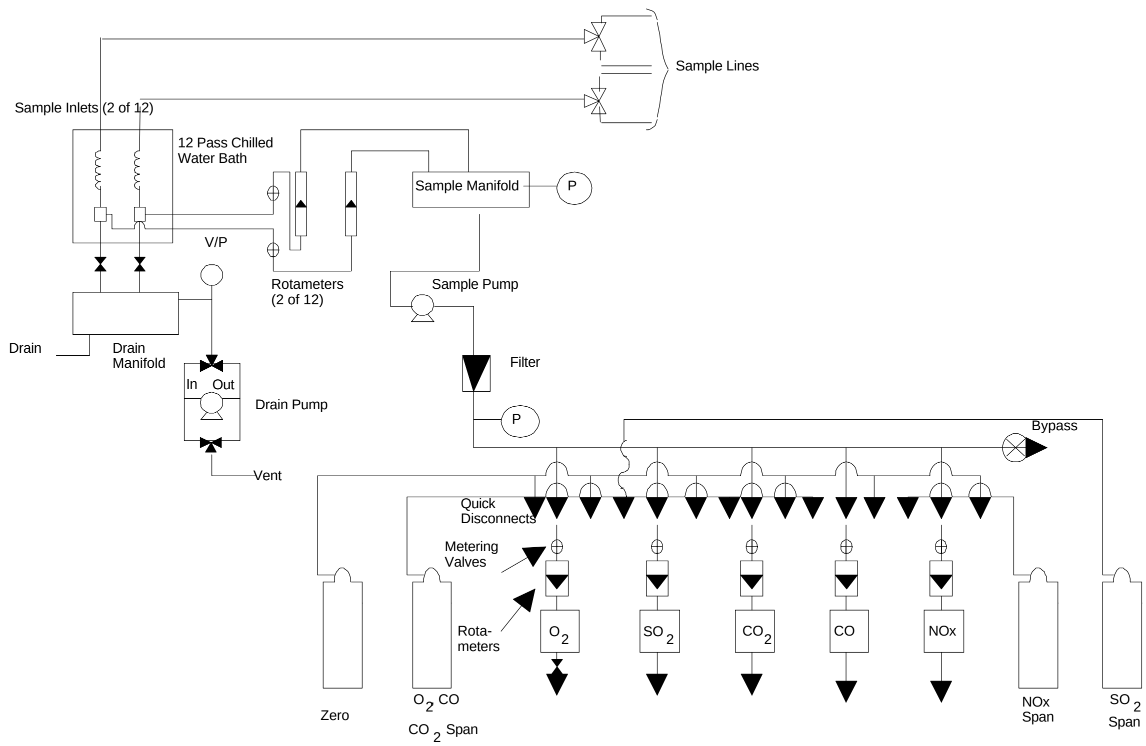


Figure 3-1
Gas Sample Handling System

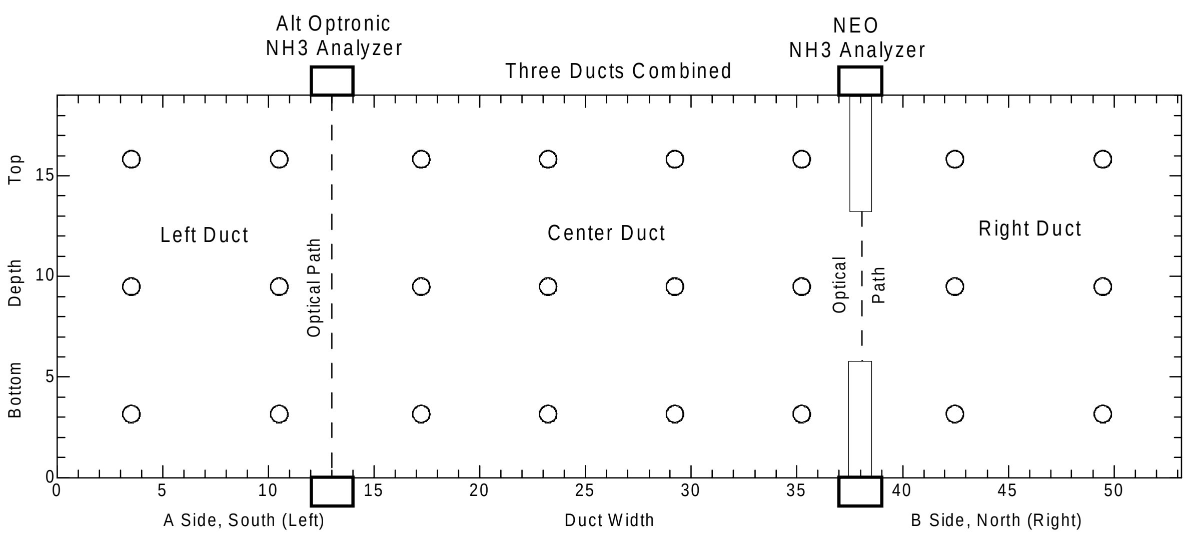


Figure 3-2
Economizer Exit Probe Locations

Gaseous samples were extracted through stainless steel probes; external filters were used at the outlet of each probe to reduce particulate loading. The samples were then drawn through inert polyethylene sample lines into a refrigerated (38°F, 3°C) dryer for moisture removal. The sample then entered the dual-head, diaphragm pump. All sample-wetted components of the pump are stainless steel or Teflon. The pressurized sample leaving the pump flows to the analyzers. Excess sample is vented through a back-pressure regulator, maintaining a constant pressure to the analyzers.

The analyzers calibrated with gases certified to ±1% calibration by the manufacturer to comply with reference method requirements. The cylinders are equipped with pressure regulators which supply the calibration gas to the analyzers at the same pressure and flow rate as the sample. The selection of zero, span, or sample gas directed to each analyzer is accomplished by operation of the sample/calibration selector valves.

Table 3-1 lists the analyzers used for this test program.

Table 3-1
Continuous Gas Analyzers

Species	Analyzers	Measurement Principle
NO/NO_x	TECO 10A	Chemiluminescent
N_2O	Siemens Ultramat 5E	NDIR
O_2	Siemens Oxymat 5E	Paramagnetic
CO	Horiba PIR2000	NDIR
CO_2	Horiba PIR2000	NDIR
SO_2	Siemens Ultramat 5E	NDIR

3.2 NO/O_2/CO Profiles

An important aspect of SNCR optimization is the distribution of chemical and the resulting stratification of NO_x removal and NH_3 slip. The NO_x removal and NH_3 slip will vary not only due to non-uniform chemical distribution, but also with temperature variations at the injection plane. To assess local NO_x reductions and slip, point-by-point measurements need to be made at the exit of the economizer (i.e., it is possible that one localized low-temperature region, or a small region with excess chemical, could be contributing a majority of the NH_3 slip).

To simplify these point-by-point measurements, FERCo has developed a system that is capable of simultaneously monitoring the NO, O_2, and CO levels for up to twelve separate sample points in the economizer exit duct. This analyzer system allows the duct emissions profiles to be characterized in a matter of minutes, as opposed to hours for traditional duct emission traverse techniques. Data from twelve sample lines are taken every ten seconds, and a contour plot of O_2, NO and CO is shown in “real time” on the computer screen. Figure 3-3 shows a general arrangement of this system.

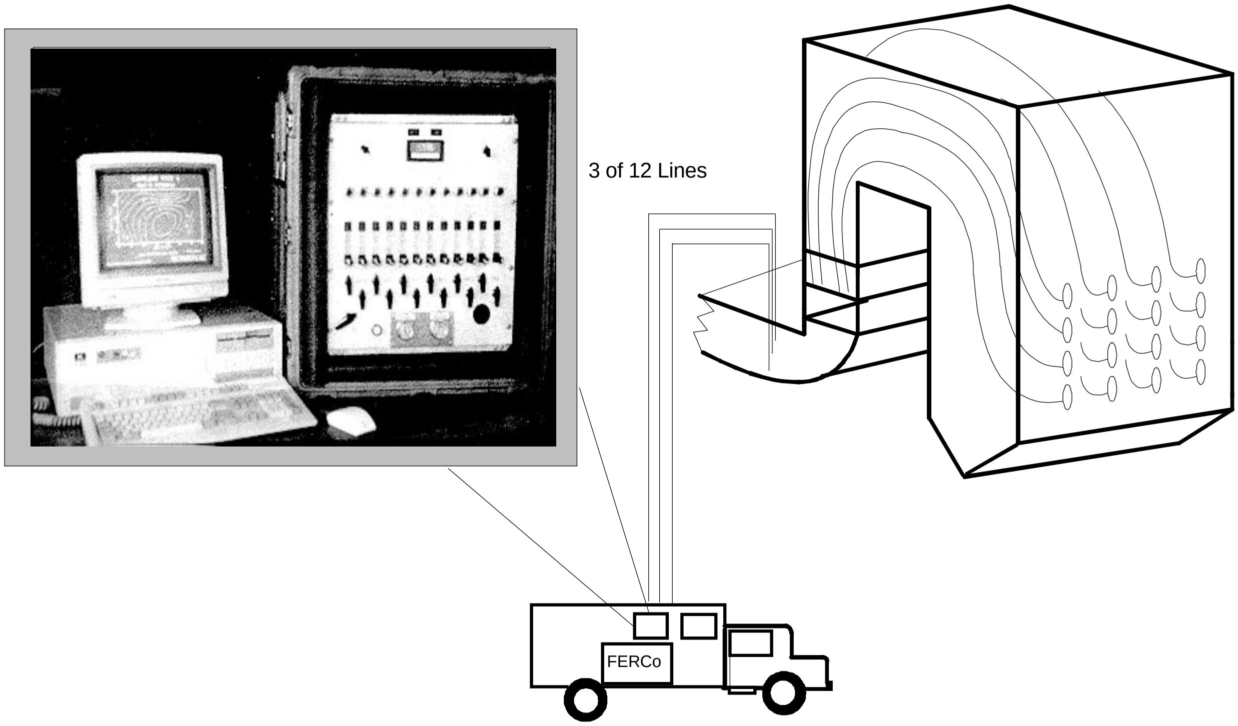


Figure 3-3
Multipoint Multigas Combustion Diagnostic Analyzer

3.3 Wet Chemical NH_3 Slip Measurements

Ammonia slip measurements were made using a batch wet chemical technique. This method involves sampling a measured portion of the flue gas and collecting the condensed ammonia vapors in a wet chemical sampling train. The ammonia content of the samples is then determined using an ammonia ion-specific electrode. This method allows same-day turnaround of ammonia samples while in the field.

The ammonia sample was taken from a probe located inside one of the gas sampling probes. The sample was withdrawn using a low-flow-rate (e.g., 15-20 scfh [0.4-0.6 m^3/hr]) sample pump. This sample then passed through three impingers. The first two impingers contain 0.02 N sulfuric acid (H_2SO_4) and the final impinger was dry. Nominally two cubic feet of flue gas are passed through the impinger train during each test at a rate of about 0.2 ft^3 per minute (0.3 m^3 per hour). Following each sample run, the sample probe, Teflon line and sampling train glassware were washed with dilute H_2SO_4 into the bottle containing the impinger solution. Figure 3-4 shows the sample train schematic.

To allow NH_3 samples to be obtained throughout the economizer exit duct, a “tee” was added at the exit of each stainless steel sample probe at the economizer exit. A shorter probe, nominally six feet (1.8m) in length, was inserted into the sample probe, and the sample withdrawn and passed through the NH_3 train. A schematic of this arrangement is shown in Figure 3-5. At the existing economizer exit temperatures, NH_3 will not deposit on the stainless steel sample probes, so it was only necessary to have a sample probe long enough that it was inserted well into the duct. This system facilitated taking either single-point NH_3 samples in the duct or composite samples. Composite samples were obtained by sampling a prescribed volume of gas from each probe.

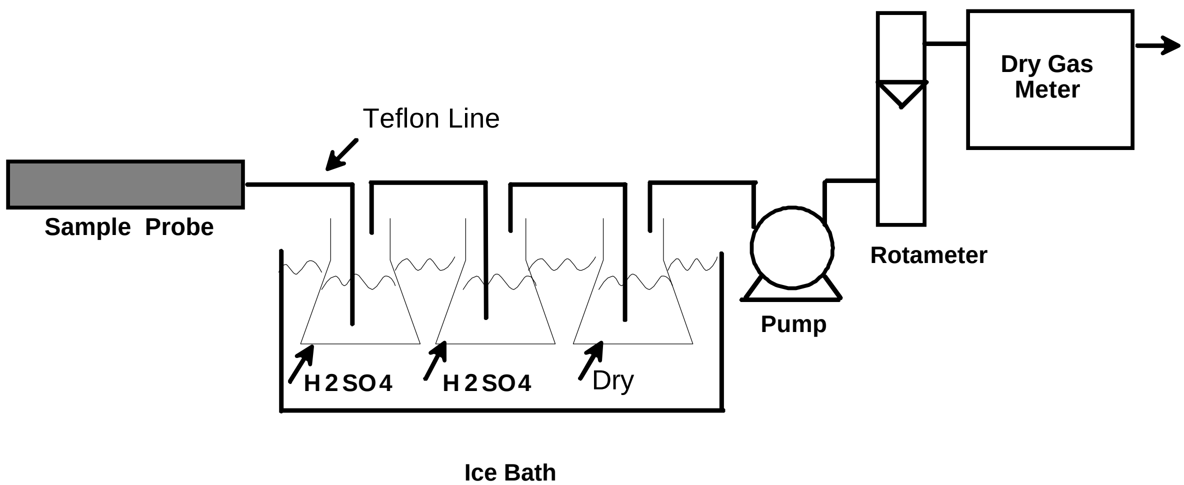


Figure 3-4
Ammonia Sampling Train Schematic

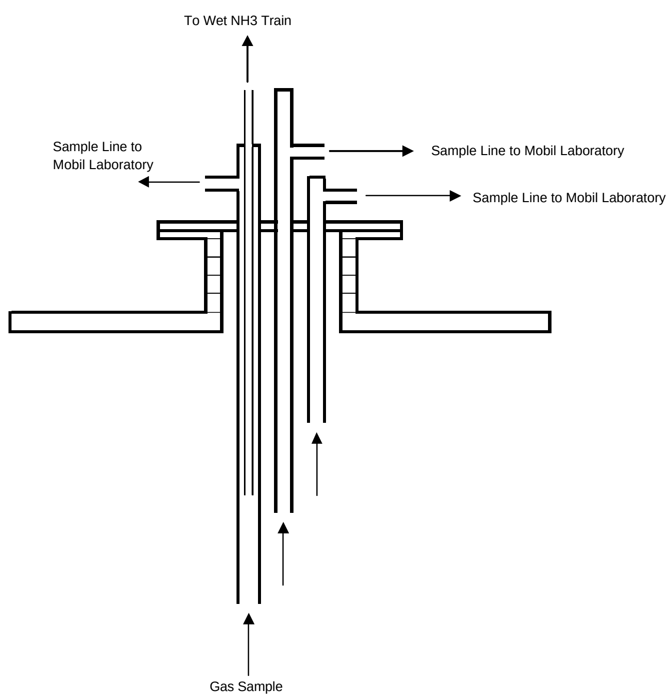


Figure 3-5
Gaseous and NH_3 Sampling Configuration

The samples were analyzed using an ammonia ion-specific electrode. The electrode is gas sensitive, and uses a hydrophobic, gas permeable membrane to separate the sample solution from the electrode internal solution. Dissolved ammonia in the sample diffuses through the membrane until the partial pressure of ammonia is equal on both sides of the membrane. In any sample, the partial pressure of the ammonia is proportional to its concentration. The ion-specific electrode was calibrated daily with NH_4Cl solutions of known concentration.

3.4 Sulfur Trioxide (SO_3)

The measurement of SO_3 concentration was performed using the Goksoyr-Ross Controlled Condensation technique, which selectively retains the SO_3 while preventing SO_2 capture. This method is desirable because of its simplicity and clean separation of particulate matter and SO_3 from the remainder of the effluents. The procedure is based on the separation of SO_3 (H_2SO_4) from SO_2 by cooling the gas stream below the H_2SO_4 dew point while maintaining it above the H_2O dew point. Figure 3-6 shows the sample train used for these measurements. Particulate matter is first removed from the exhaust gas stream by means of a quartz glass filter placed in the end of the quartz-lined sample probe. Heating tape is used to maintain a minimum gas exit temperature of 500°F (260°C) in the probe. This temperature ensures that none of the H_2SO_4 will condense in the probe. The condensation coil, where the H_2SO_4 is collected, utilizes a circulating water bath to maintain its temperature between 140°F and 165°F (60°C and 74°C). This maintains the exhaust gas temperature between the H_2SO_4 and H_2O dew points.

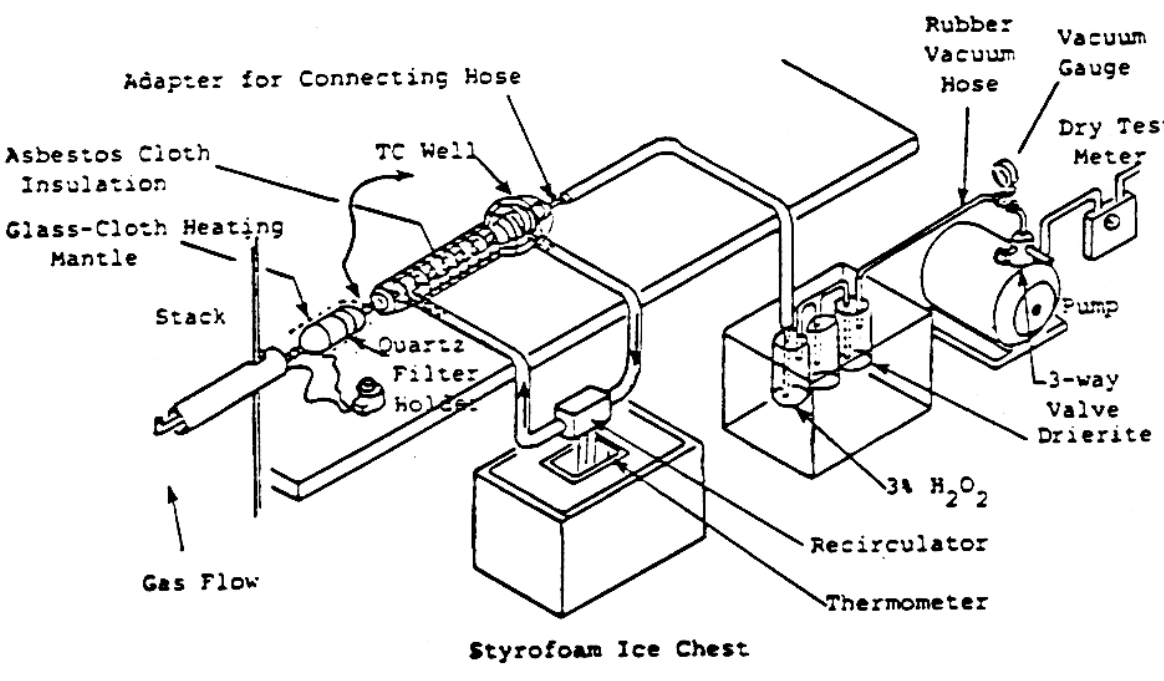


Figure 3-6
Schematic of Goksoyr-Ross Controlled Condensation System (CCS) for SO_3

Once the sampling is completed, the probe filter is recovered and placed in a sample jar. The probe is washed with distilled water; this wash is also placed in the jar containing the probe filter. The coil is then washed with distilled water; this wash is placed in a separate sample container. The wash from the coil is analyzed for sulfate (SO_4^{-2}) by an outside laboratory using ion chromatography. The SO_3 in the flue gas is calculated from the volume and sulfate concentration of the coil wash solution, and the amount of flue gas sampled through the coil.

3.5 Ash NH_3

Ash ammonia measurements were made using a grab sample from selected ESP hoppers. A measured portion of the sample was placed in dilute sulfuric acid, and the resulting solution was then analyzed for NH_3 content using an ammonia ion-specific electrode.

The ash samples were taken primarily from hopper 1-4, which is in the first row of ESP hoppers. Several samples were also taken from hopper 2-4. Once the ash sample was allowed to cool, 10 grams of ash were placed in a container with about 220 ml of 0.02 N H_2SO_4. The container was covered and shaken to mix the ash and H_2SO_4. The resulting solution was allowed to stand overnight to ensure that any ammonia in the ash was in solution. The liquid was then analyzed using the ammonia ion-specific electrode described above.

3.6 Continuous Ammonia Monitors

For the long-term tests, two continuous ammonia monitors were installed in the economizer exit duct; one on the North side and one on the South side. Both instruments were *in situ* analyzers which use tunable diode infrared lasers to measure NH_3 along a line of site across the duct. The instruments were supplied by Norsk Elektro Optikk (NEO) and AltOptronic. Figure 3-2 shows the location of the continuous ammonia monitors relative to the grid of gas sampling probes at the economizer exit. Each of the instruments is described below.

3.6.1 NEO Laser Instrument

The NEO NH_3 instrument is an *in situ* infrared laser-based analyzer manufactured by Norsk Elektro Optikk. The analyzer optical system was mounted on four-inch flanged ports installed on the economizer exit duct. The transmitter and receiver are located on opposite sides of the duct, and the analyzer operates with a single pass of the laser through the flue gases. Figure 3-7 shows the general installation of the NEO instrument. There is no preconditioning of the flue gases prior to passing into the NEO path; therefore, the instrument must be able to handle an ash-laden gas stream at duct operating conditions.

The NEO Laser instrument was installed in the North economizer exit duct. This duct is 21 feet (6.4m) deep at this location. The duct was sufficiently deep that air purged shields were required to limit the exposed path length of the infrared laser beam. The shields that were installed at both front and rear ports limited the effective optical path length to approximately 11 feet (3.4m) in the center of the duct. Purge air was required to keep the optical windows and shields free from dust accumulation.

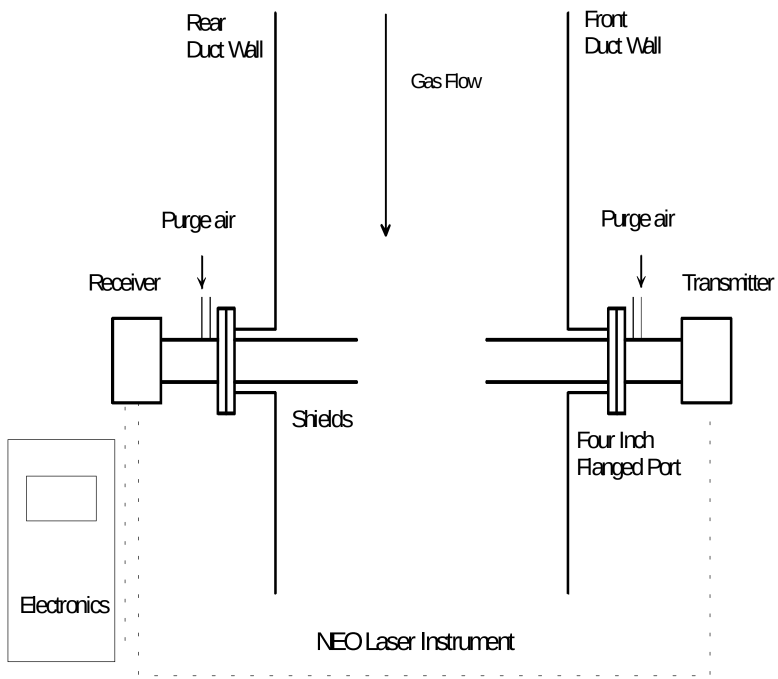


Figure 3-7
NEO NH_3 Analyzer

The NEO instrument measurement principle is called infrared single-line absorption spectroscopy and is based on the fact that most gases absorb light at specific wavelengths. The absorption is a direct function of the specific gas concentration in the gas passing through the optical path.

The diode laser wavelength is scanned across a chosen NH_3 absorption line, and the detected light varies as a function of the laser wavelength only, due to the absorption by the NH_3 gas molecules in the optical path between the diode laser and detector. To increase the sensitivity, the so-called wavelength modulation technique is employed. In this method, the laser wavelength is modulated a small amount while scanning the absorption line. The detector signal is spectrally decomposed into frequency components at harmonics of the laser modulation frequency. The second harmonic signal is used to measure the concentration of the absorbing gas. Since absorption lines from other gases are not present at this specific wavelength, there is no direct interference with other gases. The measured gas concentration is thus proportional to the absorption line amplitude.

There is, however, another type of interference which may influence the measured concentration. This is the line broadening effect originating from molecular collisions. Different types of molecules may broaden the absorption line differently. For example, the linewidth of the absorption line may vary by a factor of 1.5 when the concentration of water vapor varies from 0 to 30 volume %. This decreases the absorption line amplitude by about the same amount, even if all the other gas parameters remain constant. This, in turn, results in a decrease in the measured concentration if the variations of the linewidth are not taken into account. The NEO instrument automatically compensates for any variation of the absorption line width caused by other gases by extracting the line width information from the measured second harmonic signal, using an advanced digital filtering technique to compensate for the change in line width.

3.6.2 AltOptronic Instrument

The AltOptronic configuration and general operating principle is also an infrared-laser-based *in situ* system, similar to the NEO instrument. Referring back to Figure 3-7, the general configuration appears the same as the NEO, with the laser transmitter and receiver optics located on opposite sides of the duct.

In contrast to the NEO, the AltOptronic required no shields and, in effect, measured across the full duct width (approximately 21 feet [6.4m]). The instrument also has a remotely located control unit and electronics; light signals are transported to the control unit from the receiver and transmitter by fiber optics. Thus, the AltOptronic system can monitor up to three locations simultaneously.

Similar to the NEO instrument, the AltOptronic instrument is based on line absorption spectroscopy using a tunable infrared laser. However, the actual measurement with the AltOptronic instrument is somewhat different than the NEO instrument. With the AltOptronic, the NH_3 gas is identified by comparing the absorption across the duct with the absorption through a built-in reference cell containing NH_3. The laser light is split into three beams. The first beam passes through a reference gas and is then detected. This reference signal is used for continuous self-calibration and zero point determination of the system, taking temperature and pressure into account. The second beam is used for measuring the intensity of the laser and provides the control unit with information relating to the state of the laser. The third beam is conducted via the optical fiber where it enters the measuring section. When the laser light passes through the gas in the measuring section, it is partially absorbed. The light is detected by the receiver and, after signal conditioning, the signal is converted to an optical signal and returned to the central unit using the multimode optical fiber.

3.7 Furnace Temperature Monitor

Fuel Tech has recently been incorporating a furnace temperature monitor called Spectratemp® into their SNCR systems. The Spectratemp® instrument incorporates optical techniques to measure temperature in real time. The optical temperature measurements can then be either integrated into the SNCR control system, or used by the operators to control sootblowing in order to maintain near constant temperatures in the upper furnace.

The Spectratemp® instrument detects radiation primarily at visible wavelengths, where its accuracy is maximized, while minimizing errors resulting from the relatively cool walls that surround the gas. This visible radiation is emitted by the ash particles transported by the exhaust gases, and not by the gases themselves. Since the ash particles are typically smaller than 30 μm in diameter and thermally equilibrate with the surrounding gas in a few tens of microseconds, their temperature is said to accurately reflect the local gas temperature.

An optics tube collects radiation emitted by the hot particles contained within a narrow field of view. That radiation is projected onto a fiber optic bundle that carries the radiation to a group of photodetectors. An optical filter is placed in front of each photodetector to limit the detected radiation to a specific narrow band of wavelengths. The photodetectors convert the incident radiation into measurable voltages which, after amplification, are digitized and supplied to an internal microprocessor. The microprocessor has been pre-programmed to utilize the information to calculate the temperature of the ash cloud.

4
OPTIMIZATION TEST RESULTS

The goal of the test program was to complete the optimization of a commercial SNCR installation. The optimization testing began on March 15 and was completed on April 27, 1999. During this period, 226 tests were performed. Appendix A contains a summary of the test results presented in chronological order, and Appendix B contains a data summary sorted by boiler load.

Systematic procedures were followed during the optimization tests. At the start of each day, a baseline test was performed once the unit was operating under steady-state conditions at the desired test load. Following the baseline test, the SNCR system was turned on, and a test conducted. Depending on the steadiness of unit operation, additional baseline tests were performed between the SNCR tests. A baseline test was also performed at the end of each day. These baseline data were used to determine NO_x reductions for each SNCR test condition.

Note that there are two NO_x reduction values shown on the data summaries: one based on the FERCo system and one based on the CEM data. During the course of an SNCR test, there could be some changes in the boiler O_2 level between the time the baseline data was collected, and the time the data was collected with urea injection. Since NO_x is a function of O_2, these changes in O_2 will affect the baseline NO_x level. In order to calculate the NO_x reduction from the FERCo data, the NO_x emissions for the baseline condition were first corrected to the same O_2 level as the corresponding SNCR test. The correlation used for this correction was as follows:

$$NO_{x2} = NO_{x(1)} + (O_{2(2)} - O_{2(1)})\ (0.049)$$

where:

NO_x is measured in lb/MMBtu,
O_2 is measured in %,
the subscript 1 indicates the measured baseline value, and
the subscript 2 indicates the value corrected to SNCR conditions.

This correlation of NO_x versus O_2 was developed during the LNB tests prior to startup of the SNCR system. Thus, the NO_x reductions reported under the "Calculated Data" heading were based on equivalent O_2 levels. In comparison, the NO_x reductions reported under the "CEM Data" heading were based only on reported NO_x measurements, and were not corrected to equivalent O_2, levels. Figure 4-1 shows the two NO_x reduction values plotted versus each other.

The figure shows data from the individual tests with a line representing a one-to-one correspondence. While on an overall basis the two methods agree within 2% (i.e., the slope of the line in Figure 4-1 is 1.016), there can be greater differences in the individual points. The NO_x reduction values reported hereafter in this section of the report are based on the FERCo data corrected for O_2, as discussed above.

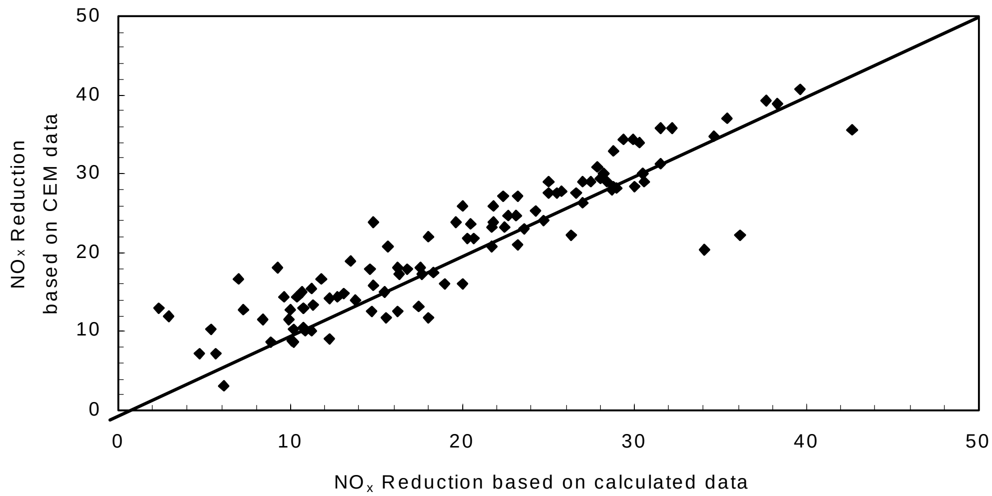


Figure 4-1
Comparison of NO_x Reductions Calculated from FERCo and CEM Data, AEP Cardinal Unit 1

The optimization tests were performed at three primary loads: 600 MW, 450 MW and 350 MW. Limited numbers of tests were also performed at 530 MW and 410 MW. The results for tests performed at the three primary test loads are presented below. The discussions of test results at each load are divided into two subsections. The first subsection provides an overview of the test results using the emissions data obtained with the FERCo mobile emissions laboratory. The second section reviews the contour plots generated using the FERCo multipoint analyzer.

4.1 600-MW Test Results

<u>Overview</u>

The data included in this subsection were recorded at loads ranging from 573 to 618 MW, and are considered to be the "full-load" test data. A total of 92 full-load tests was performed during the optimization testing, as shown in Appendix B.

Figure 4-2 shows NO_x reduction plotted versus the normalized stoichiometric ratio (NSR) for the 600-MW tests. The NSR is defined as follows:

$$NSR = (\text{moles N injected})/(\text{moles initial } NO_x)$$

For urea, this can be rewritten as

$$NSR = 2 * (\text{moles urea injected})/(\text{moles initial } NO_x)$$

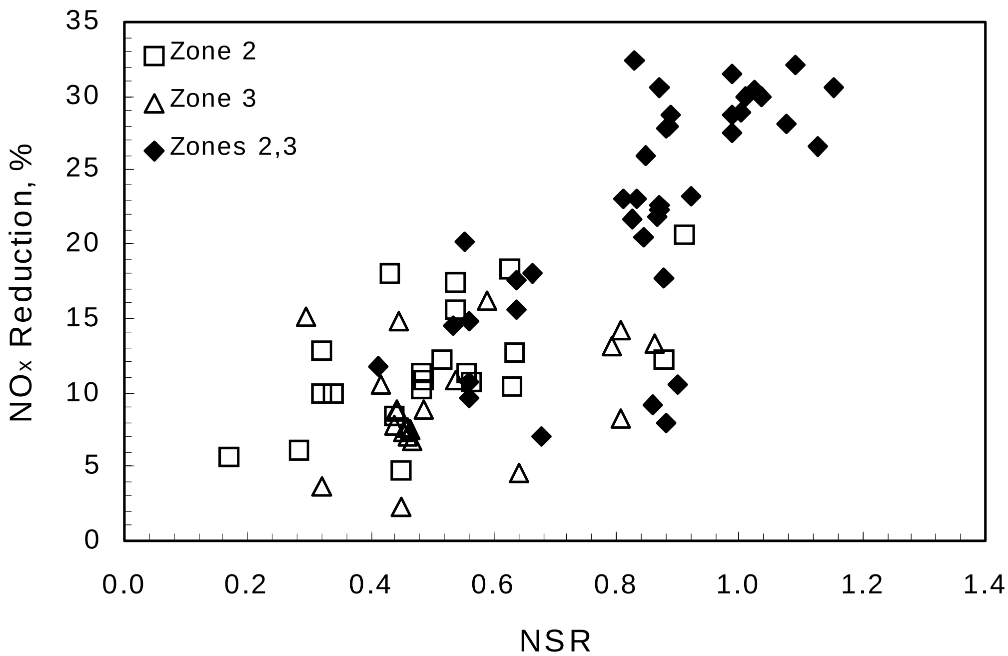


Figure 4-2
NO_x Reduction versus NSR, AEP Cardinal Unit 1, 600 MW

Note that several tests performed using Zone 1 are not included. These data were left out because they showed that Zone 1 temperature was too high for full-load injection. Data are shown for injection at Zone 2, Zone 3 and combined Zones 2 and 3. The range of reductions at a given NSR is due to a number of factors. The data included in Figure 4-2 comprise test conditions with varying injectors in service at each level, different atomization air pressures, and changing dilution water flows. In addition, varying furnace conditions also contribute to the variations in NO_x reductions. At a fixed NSR, injection at Zone 2 generally provided higher NO_x reductions than injection at Zone 3. Combining injection Zones 2 and 3 generally provided superior NO_x reduction compared to injection at the individual zones.

The corresponding ammonia slip data are shown in Figure 4-3. Note that there are less ammonia slip data, since ammonia measurements were not made at each test condition. Ammonia slip levels measured when injecting in Zone 3 were generally lower than those measured when injecting in Zone 2. This is somewhat contrary to what intuition might suggest, as the Zone 2 injectors are located in a hotter region of the furnace than the Zone 3 injectors. However, the chemical injected at Zone 2 may be carried vertically up towards the roof into a lower-temperature region. At the same time, the chemical from Zone 3 may treat the higher-temperature gas flowing around the boiler nose. The NH_3 slip with Zone 3 is lower than with Zone 2 at this load. This is consistent with the lower NO_x reduction from Zone 3 compared to Zone 2 due to higher-temperature gas at Zone 3. Injection using Zones 2 and 3 resulted in NH_3 slip levels between 2 and 8 ppm at NSRs between 0.8 and 1.0.

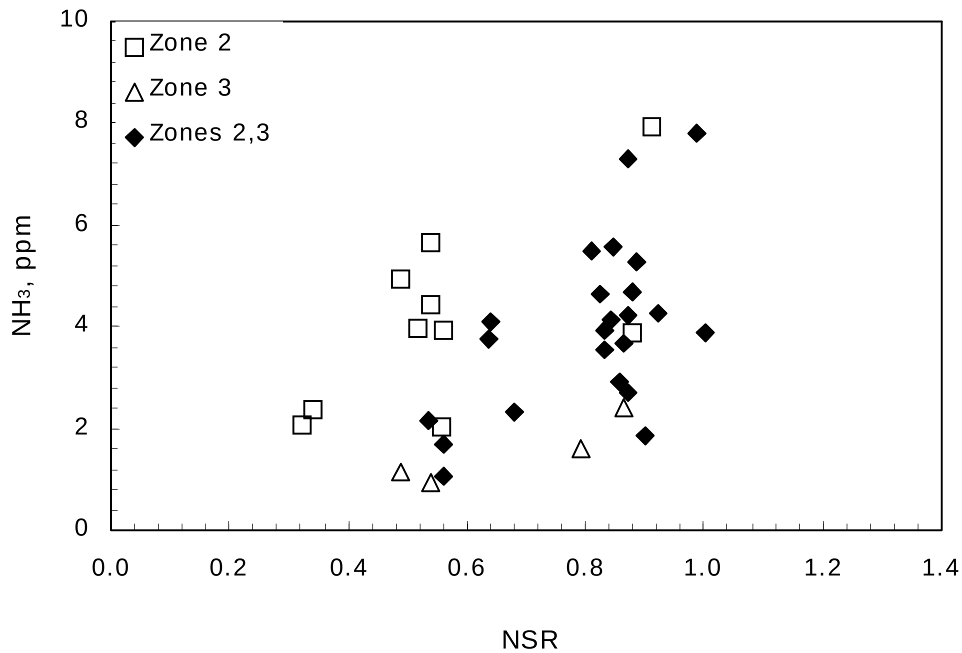


Figure 4-3
Ammonia Slip versus NSR, AEP Cardinal Unit 1, 600 MW

The NO_x reduction and NH_3 slip data are cross-plotted in Figure 4-4. In this figure, a line has been drawn to define the upper boundary, which represents the performance under optimized conditions. These data show that while maintaining the NH_3 slip below the 5-ppm target, initial tests repeatedly demonstrated NO_x reductions of 20 to 25 percent. Through the optimization tests, the reductions improved to 25 to 35 percent with NH_3 slip at or below 5 ppm. Note that the individual data points represent, in many cases, data from non-optimized test conditions.

<u>N_2O Measurements</u>

N_2O measurements were made at each test condition during the optimization testing. The N_2O emissions varied depending primarily on the injection zones in service and the urea flow rate. Data taken during the tests, which define the upper boundary of Figure 4-4, were reviewed and are summarized in Table 4-1. For comparison purposes, it is customary to consider the ratio of N_2O produced to NO_x reduced when evaluating data from SNCR systems (i.e., the fraction of the NO_x reduced that is converted to N_2O). The $\Delta N_2O/\Delta NO_x$ ratio varied from 9.7 to 13.6 percent at full load. These ratios are typical of those measured at other utility urea injection sites. [2]

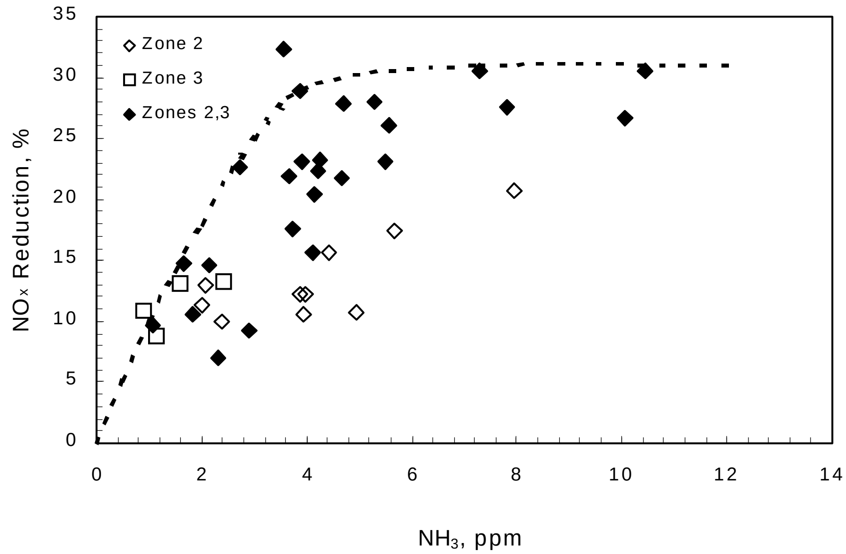


Figure 4-4
Relationship between NO_x Reduction and NH_3 Slip, AEP Cardinal Unit 1, 600 MW

Table 4-1
N_2O Emissions at 600 MW, AEP Cardinal Unit 1

Test No.	Load MW	Injection Levels In Service	Δ NO_x %	N_2O ppm	Δ N_2O/ΔNO_x %
120	615	2, 3	31.0	17	9.7
135	611	2, 3	29.0	19	12.0
139	611	2, 3	31.5	22	13.6

Detailed Measurements at 600 MW

During the optimization tests, the multipoint multigas analyzer was used to obtain O_2 and NO (corrected to 3% O_2) profiles from the 24-point probe grid at the economizer exit. Some of these profiles will be presented and discussed in this section to provide an understanding of the overall distribution in the furnace, along with an indication of the distribution of NO_x reduction across the furnace during urea injection.

For baseline tests without urea injection, contour plots of the O_2 (%) distribution and NO distribution (expressed in ppm corrected to 3% O_2) are presented. For urea injection tests, baseline data were collected first, followed by a data set with urea injection. These two data sets were then used to calculate the local NO_x reduction at each of the 24 probes. In these cases, a contour plot of the percent NO_x reduction is presented.

Figure 4-5 shows a side schematic of the boiler, including the general location of the economizer exit probes and the SNCR injection zones. Also included are two streamlines suggesting that if there were plug flow from the upper furnace to the probes, the short probes, at the top of the economizer duct, would correspond to the front wall. Likewise, the long probes at the bottom of the duct should then be more representative of the back wall, and the lower pair of MNLs. Obviously, some mixing will occur between the radiant furnace exit and the economizer exit, so the plug flow assumption is an oversimplification.

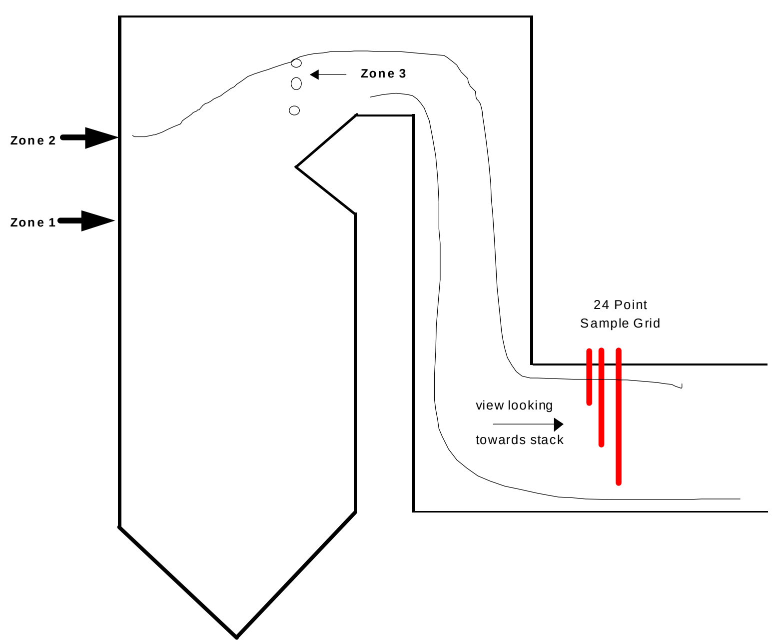


Figure 4-5
Side Schematic of AEP Cardinal Unit 1
Showing Urea Injection Zones and Gas Sampling Probes

<u>Baseline</u>

Figure 4-6 shows the baseline O_2 and NO_x profiles for full load (Test 76). The NO_x emissions are shown in ppm (dry) corrected to 3% O_2. For this test, the overall O_2 level was 4.5%. The baseline profile for Test 76 was similar to all other baseline tests throughout the optimization test program. The contour plots are a view looking from the boiler toward the stack, so that the North side is the right side of the plot. The O_2 profile exhibits low regions on both the North and South sides of the duct, with the lowest region at the bottom of the North side. Also, note the high O_2 region at the bottom of the duct toward the South side.

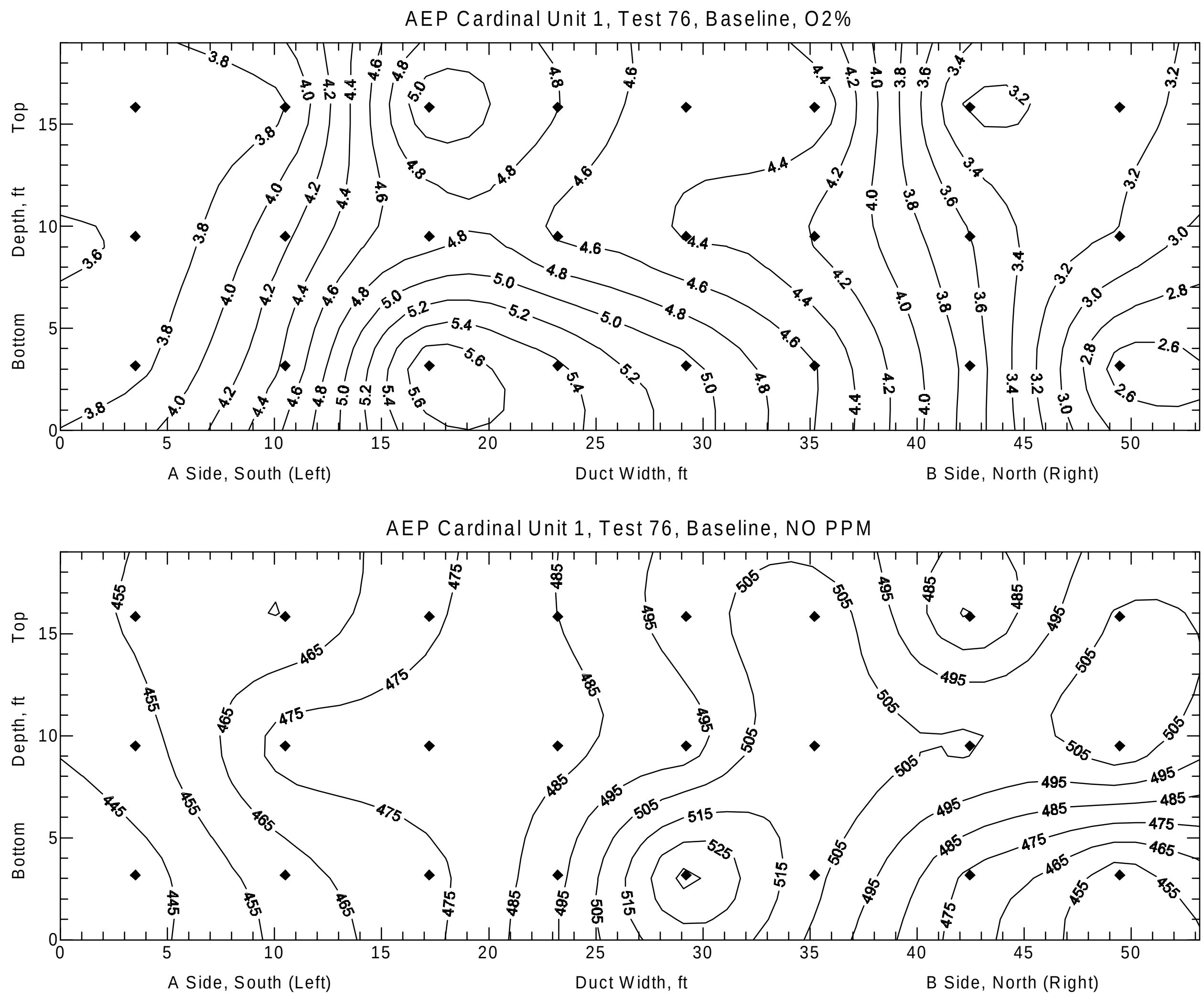


Figure 4-6
Baseline NO and O_2 Profiles,
AEP Cardinal Unit 1, 590 MW (Test 76)

The NO_x profiles in general follow the O_2 profiles with lower NO_x levels in the regions of lower O_2. One exception is the higher NO_x region at the bottom of the duct that does not correspond one-to-one with the highest O_2 region.

Figure 4-7 shows another set of baseline contours for test number 83. Once again, the NO_x emission levels shown are ppm measured on a dry basis and corrected to 3% O_2. The only difference is that the boiler is operating at a higher overall O_2 level of 5.3%. The general contours are similar to the lower-O_2 case shown in Figure 4-6. However, as will be discussed below, the NO_x reduction distribution across the economizer exit was quite different at this higher furnace O_2 concentration.

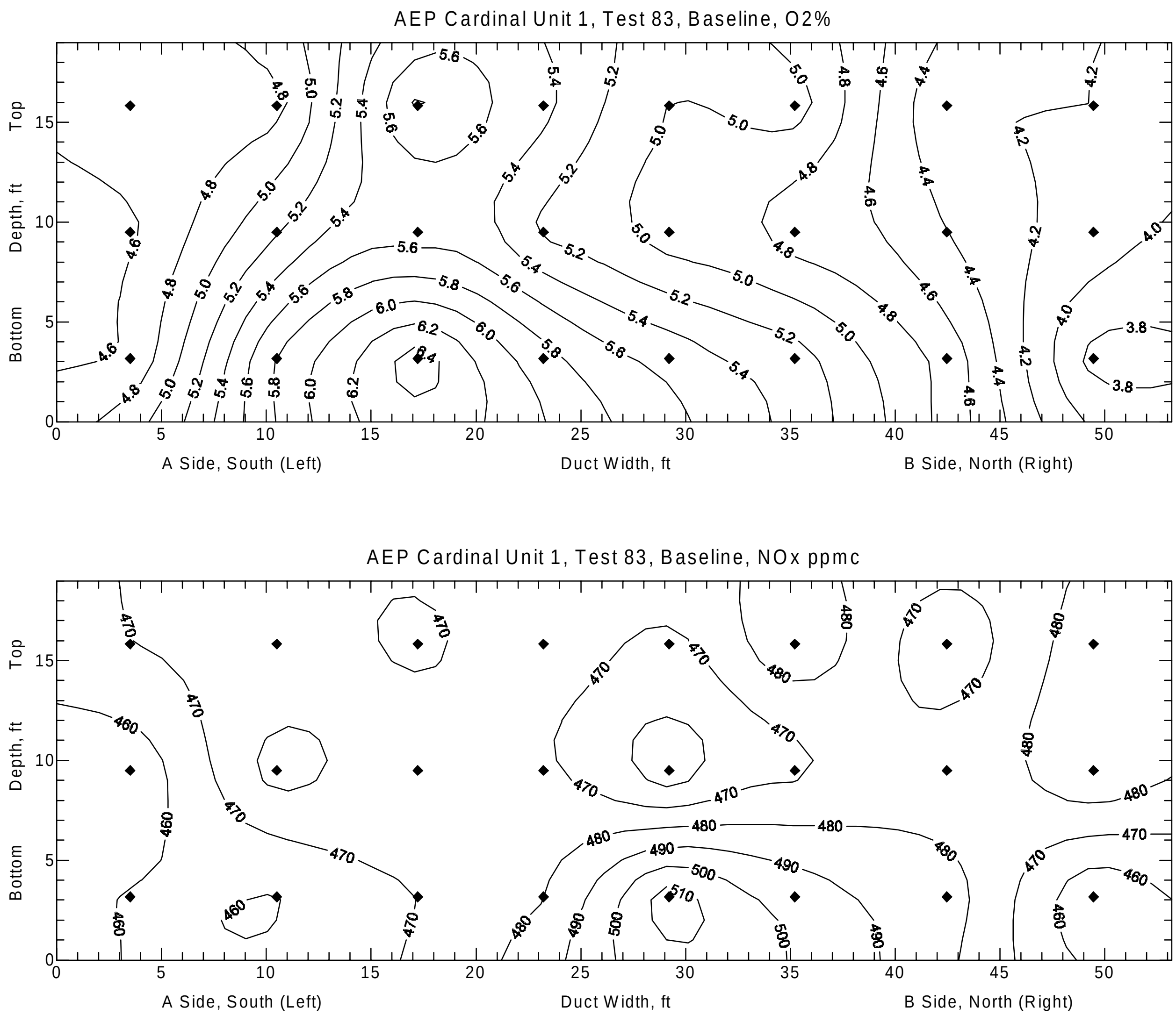


Figure 4-7
Baseline NO and O_2 Profiles at Increased O_2 Level, AEP Cardinal Unit 1, 615 MW (Test 83)

<u>Zone 2 Injection</u>

Figure 4-8 shows the distribution of NO_x removal for urea injection at Zone 2 only (Test 44). Data from test 41 were used as the baseline in preparing these plots. Recall that Zone 2 consists of front wall and side wall injectors at nominally the elevation of the nose. The Zone 2 injectors appear to penetrate sufficiently far into the furnace that the NO_x reductions are highest at the bottom of the duct. As stated earlier, the stream lines in Figure 4-5 suggest that, with little mixing, the bottom of the duct corresponds to gas originating near the nose, while the top of the duct corresponds to gas near the front wall.

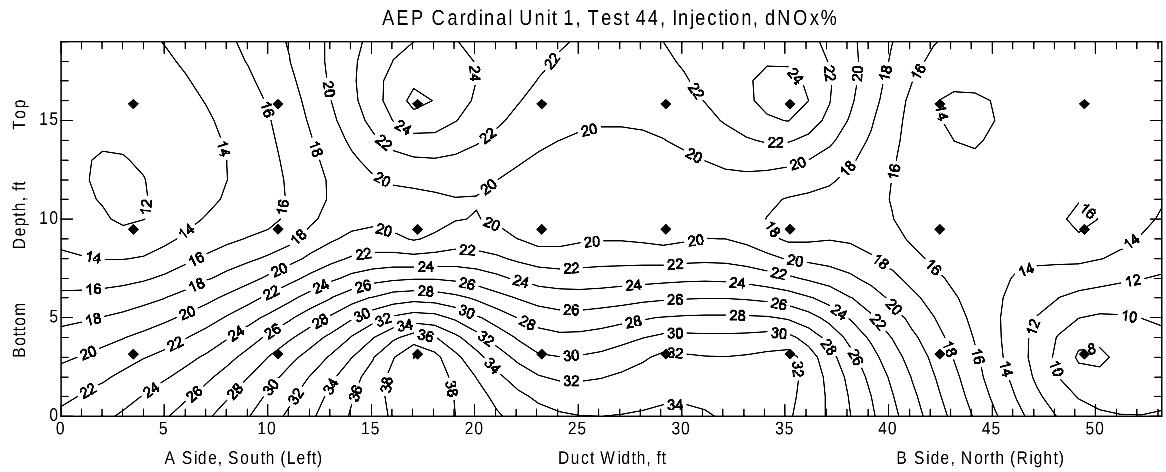


Figure 4-8
NO Reduction Profiles, Zone 2 Injection (Test 44)

The effect that the side wall injectors have can be seen in Figure 4-9 (Test 46), where the side wall injectors from Zone 2 were turned off. For this test, the urea flow rate to the front wall injectors was the same as in Figure 4-8 (Test 44). The removal of the side wall injectors resulted in a lower overall NSR, but, as expected, the NO_x reductions decreased at the outer walls.

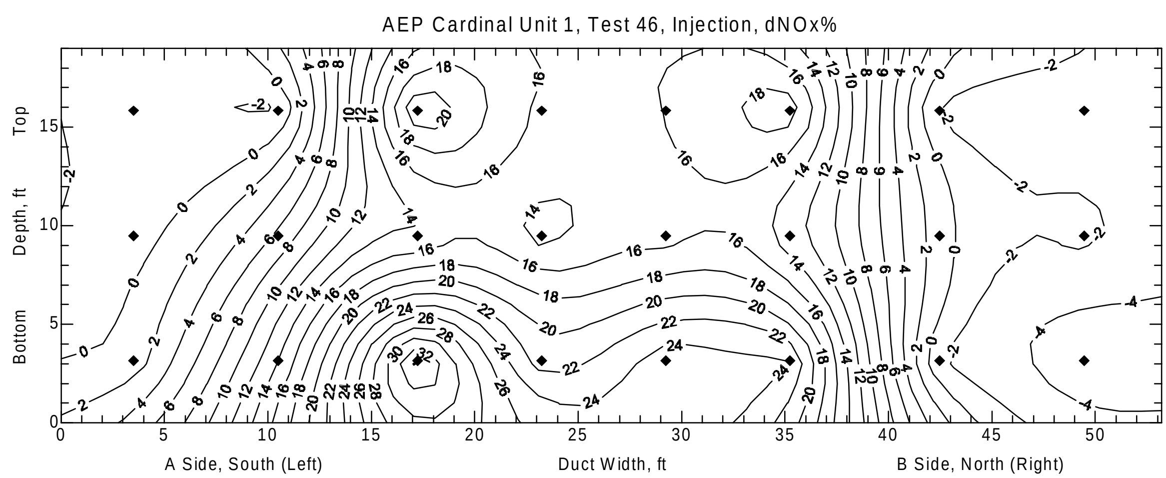


Figure 4-9
NO Reduction Profiles, Zone 2 Injection Using Only Front Wall Injectors (Test 46)

Zone 3 Injection

The next four contour plots show the NO_x reduction distributions using the Zone 3 MNLs. The first three show the NO_x reduction distributions resulting from a single pair of lances:

Figure 4-10: top pair of MNLs (C, F) – Test 28 (NSR = .32)
Figure 4-11: middle pair of MNLs (B, E) – Test 32 (NSR = .52)
Figure 4-12: bottom pair of MNLs (A, D) – Test 33 (NSR = .41)
Figure 4-13: all MNLs in service – Test 25 (NSR = 0.86)

Although the NSR varied between tests, useful comparisons can still be made. Figure 4-10 shows little NO_x reduction across the economizer exit plane with only the top pair of MNLs in service. The middle pair of MNLs result in NO_x reduction primarily on the bottom of the duct, with a large area in the center of the duct either untreated or at too high a temperature. Reductions with the bottom pair of MNLs were similar to that achieved with the middle pair (compare Figures 4-11 and 4-12). However, the reductions are lower with the bottom MNLs, suggesting injection into a higher-temperature region.

Finally, Figure 4-13 shows the NO_x reduction contours with all six MNLs in service (Test 25, NSR = 0.86). Although this test was at a lower overall NSR than the sum of the NSRs from the tests of the individual lance pairs, the NO_x reduction trends of Tests 28, 32 and 33 (Figures 4-10 through 4-12) are shown in the Figure. Note that some areas of these figures show negative NO_x reductions. These likely reflect changes in boiler NO_x profiles between the time that the baseline data were taken and the deNO_x tests run, that cannot be accounted for solely by correcting for O_2-level changes.

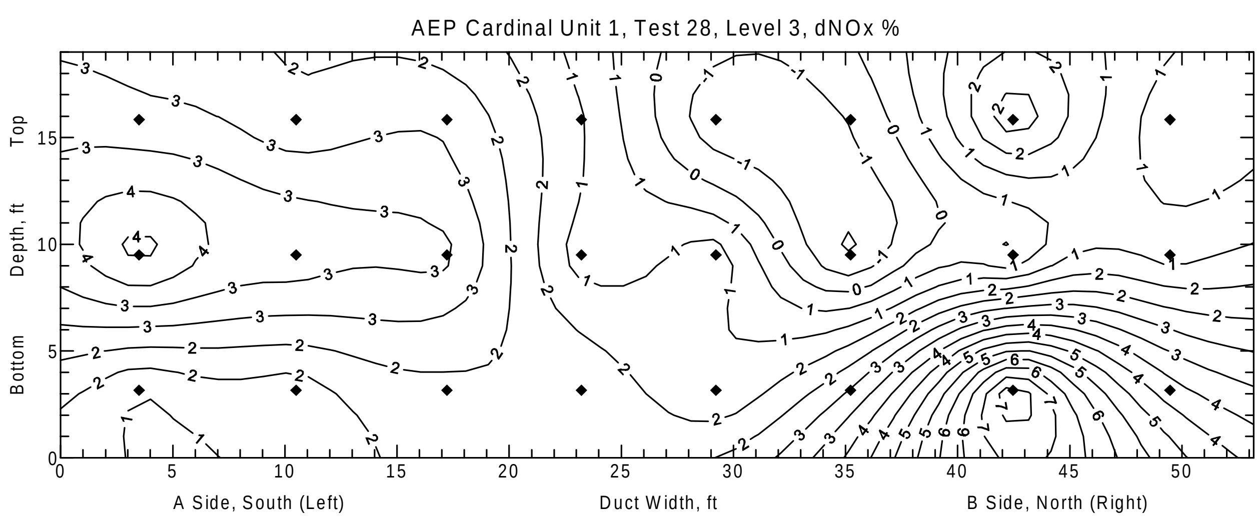


Figure 4-10
NO Reduction Profiles, Zone 3 Injection Using Top (C & F) MNLs (Test 28)

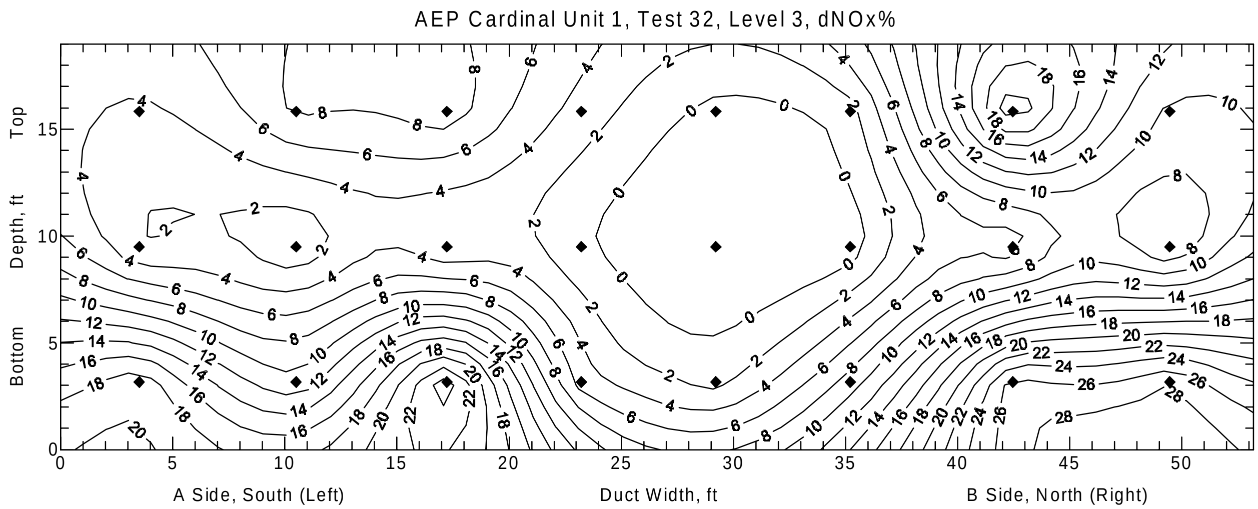


Figure 4-11
NO Reduction Profiles, Zone 3 Injection Using Middle (B & E) MNLs (Test 32)

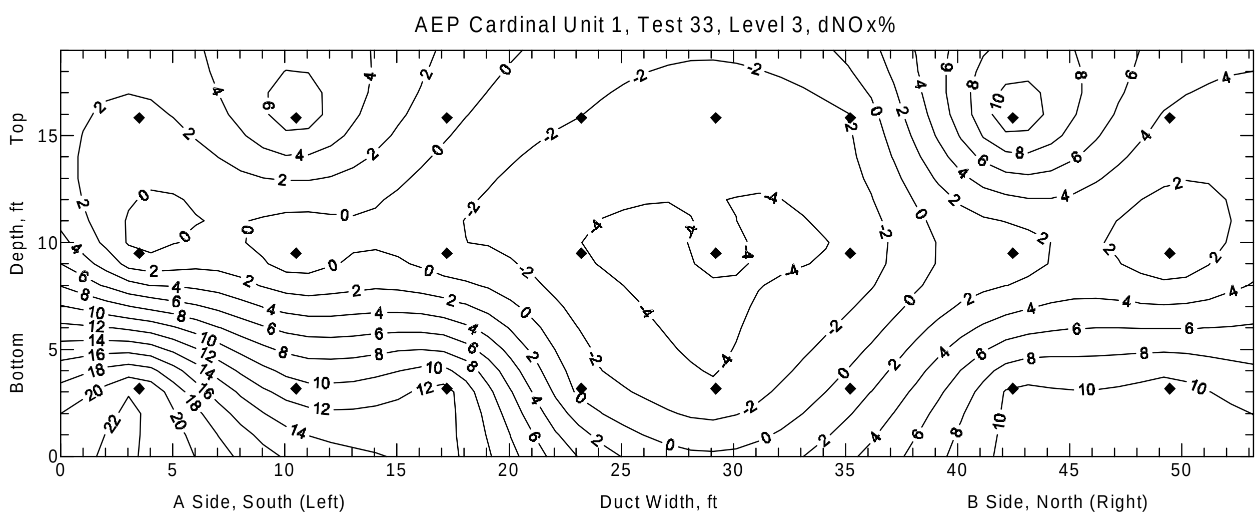


Figure 4-12
NO Reduction Profiles, Zone 3 Injection Using Bottom (A & D) MNLs (Test 33)

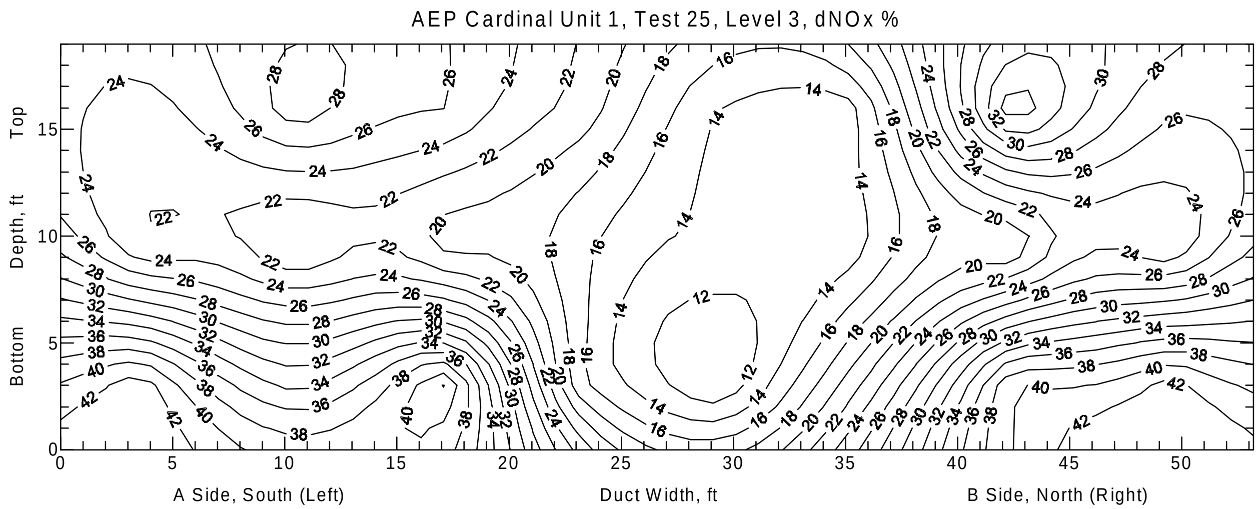


Figure 4-13
NO Reduction Profiles, Zone 3 Injection Using All MNLs (Test 26)

<u>Zones 2 and 3</u>

The preferred operating mode at full load utilizes both Zones 2 and 3. Figure 4-14 shows the NO_x reduction distribution with both zones in service (Test 80, NSR = 0.86, boiler O_2 = 4.3%). The NO_x reductions were highest on the South side of the furnace, with the highest local NO_x reduction occurring in the high-O_2 region at the bottom of the duct. Figure 4-15 (Test 84) shows the NO_x reductions for the same injection conditions as Figure 4-14, but at a higher furnace O_2 concentration, 5.3%. For this test, the NO_x reductions increased throughout the furnace, but particularly on the North side. In fact, at this higher furnace O_2 concentration, the NO_x reductions were fairly uniform across the economizer exit plane. During this period, the O_2 was increased to over 5% to mitigate a slagging problem on the North side. After the slagging problem was rectified, the furnace O_2 was reduced to nominally 4.5%. Figure 4-16 shows the NO_x reduction distribution for Test 139, which at that time was considered the optimum arrangement of Zones 2 and 3 at full load. Note that the NO_x reduction distribution for this lower O_2 concentration is similar to that for the higher furnace O_2 condition shown in Figure 4-15, yet the overall operating conditions are more similar to Test 80 (see Figure 4-14). This suggests that the furnace conditions existing in the unit before Test 80 resulted in higher temperatures on the North side, which lowered the NO_x reductions (compare Figures 4-14 and 4-16). This exercise also illustrates how small changes in furnace conditions may have fairly major impacts on the NO_x reduction process.

Two characteristics that were seen in almost all of the NO_x reduction contour plots were (1) the region of high NO_x reduction corresponding to the high O_2 region on the bottom of the duct, and (2) a region of lower NO_x reduction on the bottom of the duct in the region of lower O_2 (see Figure 4-6). To see if this could be smoothed out, the urea flow rates on the South MNLs were biased toward the South wall, while the urea flow rates on the North MNLs were biased toward the center of the furnace. The resulting NO_x reduction distribution is shown in Figure 4-17. Comparing Figures 4-17 and 4-16, it can be seen that on the South side, the NO_x reductions on

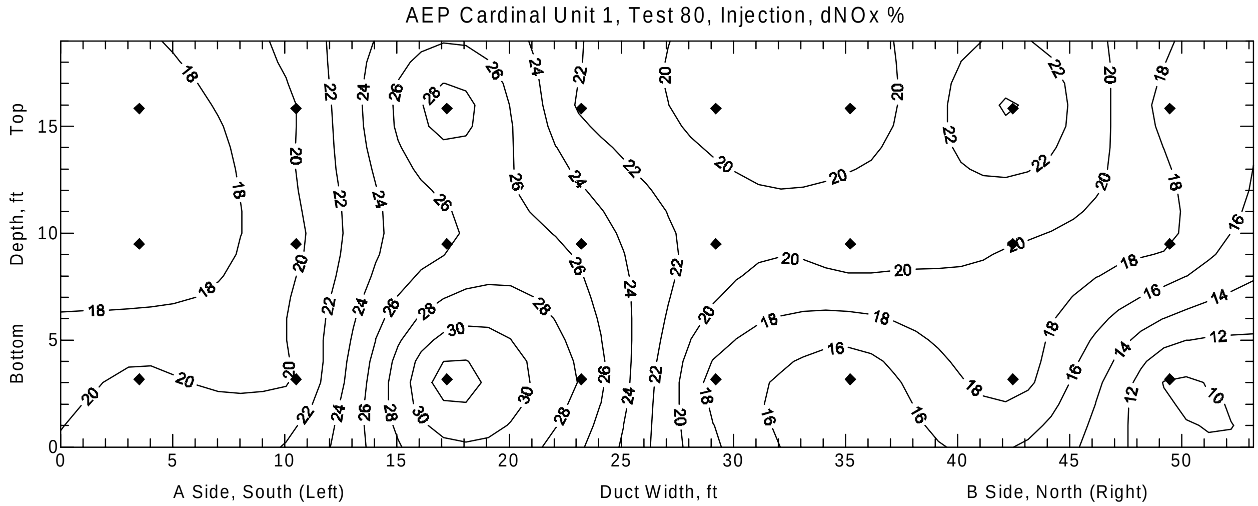


Figure 4-14
NO Reduction Profiles, Injection Using Zones 2 and 3 (Test 80)

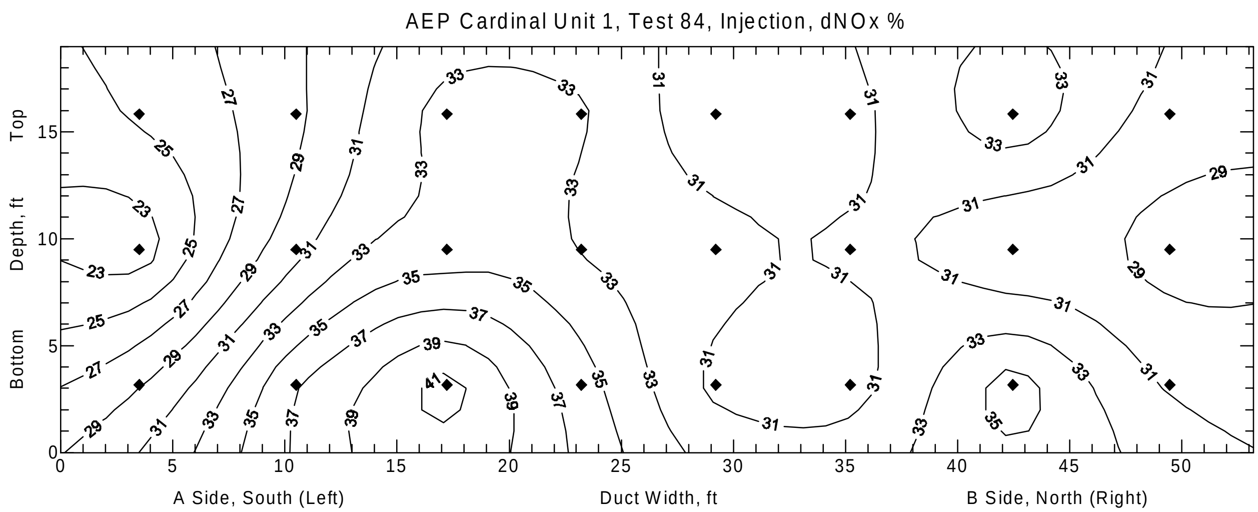


Figure 4-15
NO Reduction Profiles, Injection Using Zones 2 and 3, Increased O_2 Level (Test 84)

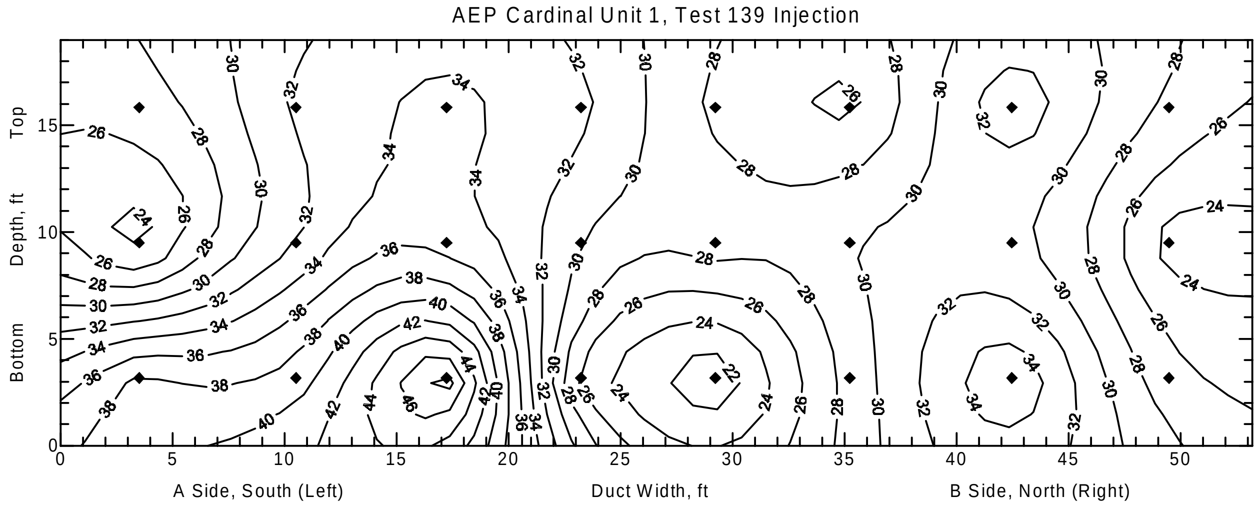


Figure 4-16
NO Reduction Profiles, Injection Using Zones 2 and 3 (Test 139)

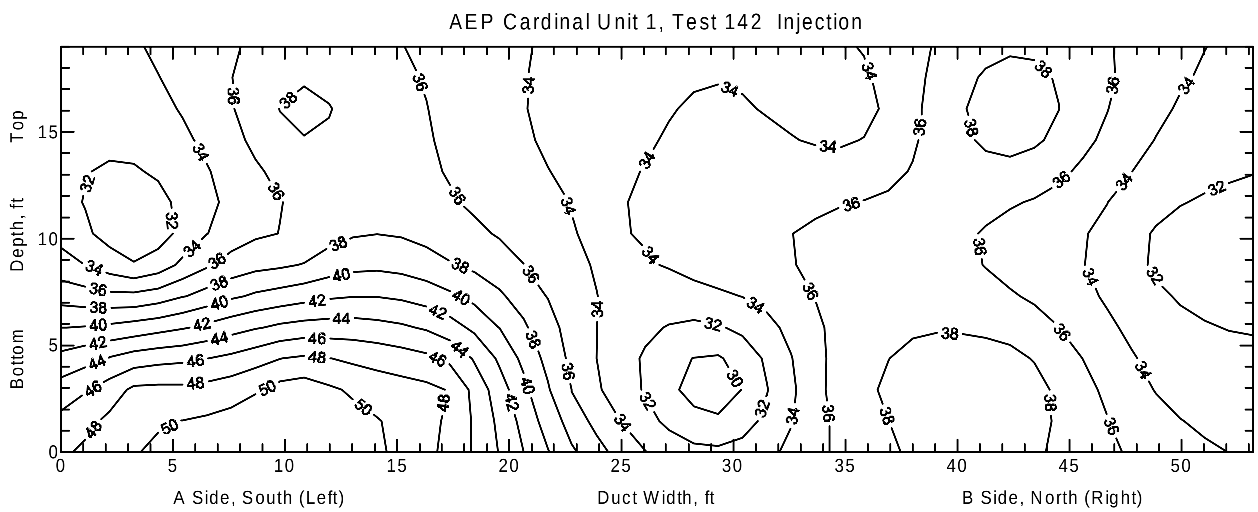


Figure 4-17
NO Reduction Profiles, Injection Using Zones 2 and 3,
Bias MNL Distribution (Test 142)

the bottom half of the duct are more evenly distributed toward the South wall. On the North side, the NO_x reductions are also more uniform, with higher NO_x reductions near the bottom center of the duct, corresponding to the higher NO_x region.

The urea injection conditions for Test 139 (Figure 4-16) were considered to be near optimum for full load. At this condition, a point-by-point NH_3 traverse was made at all 24 points at the economizer exit. For this test, the overall NSR was 1.0, resulting in a NO_x reduction of 32%. The average NH_3 slip was 10 ppm, and a contour plot of the NH_3 distribution is shown in Figure 4-18. While the preferred injection arrangement was used for this test, the NSR was too high to maintain 5-ppm NH_3 slip. This resulted in a 10-ppm average NH_3 slip. The highest levels of NH_3 slip were found across the middle of the duct. Note that the regions of highest slip do not correspond to the regions of highest NO_x reduction.

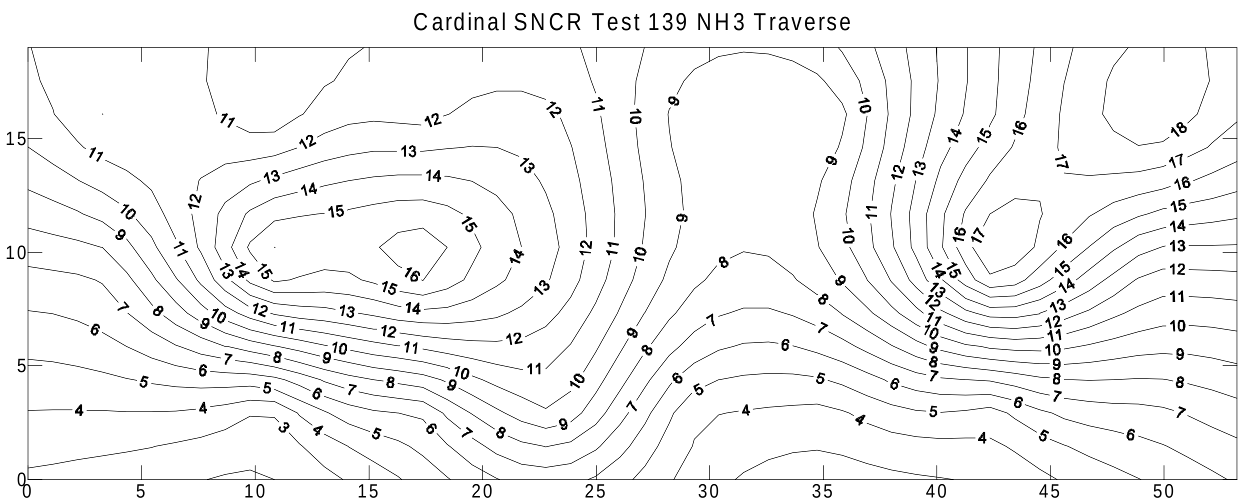


Figure 4-18
NH_3 Slip Profiles, Injection Using Zones 2 and 3 (Test 139)

4.2 450-MW Test Results

<u>Overview</u>

These tests represent the mid-load tests performed during this project. They included 21 tests performed between 450 and 471 MW. Appendix B presents a data summary for these tests.

Figure 4-19 shows NO_x reduction plotted versus NSR for all of these mid-load tests. Six different injection configurations were evaluated at this load: Zone 1, Zone 2, Zone 3, Zones 1 and 2, Zones 2 and 3, and Zones 1, 2 and 3. When injecting at a single injection level, Zones 2 and 3 provide better NO_x reduction performance relative to injection in Zone 1. At this load, the NO_x reductions were less sensitive to the combination of injection levels.

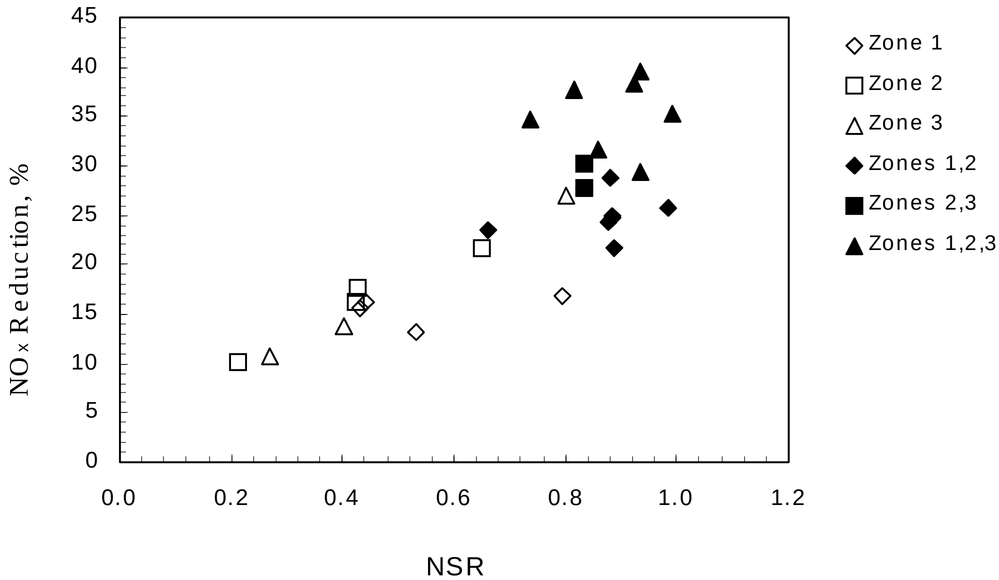


Figure 4-19
NO_x Reduction versus NSR, AEP Cardinal Unit 1, 450 MW

The corresponding NH_3 slip data are shown in Figure 4-20. When injecting at a single level, NH_3 slip decreases with increasing injection temperature, i.e., the lowest NH_3 slip values were measured when injecting into Zone 1, while Zone 3 injection resulted in the highest NH_3 slip. Similarly, injection using both Zones 1 and 2 resulted in the lowest NH_3 slip levels for the tests with injection in more than one zone.

Figure 4-21 shows the relationship between NO_x reduction and NH_3 slip observed during the mid-load tests. Similar to Figure 4-4, a line is included that defines the upper bound of performance. Multiple-level injection provided the best combination of high NO_x reduction and low ammonia slip. Based on the upper bound line, mid-load NO_x reductions as high as 38 percent could be achieved with NH_3 slip levels less than 5 ppm.

Table 4-2 summarizes the N_2O emissions measured at the points which define the upper bound in Figure 4-21. These data show that the $\Delta N_2O/\Delta NO_x$ ratio varied from 8.9 to 16.6 percent at 450 MW.

<u>Detailed Measurements</u>

Figures 4-22 and 4-23 show typical baseline O_2 and NO contours for the mid-load test condition. O_2 levels varied from 5.2 to 7.8 percent, representing a rather high O_2 stratification at the economizer sample location. The O_2 contours show O_2 levels of 7.8 percent at the bottom of the duct compared to less than 6 percent at the outer edges. NO emissions ranged from 420 to

460 ppm, a difference of nominally 10 percent, demonstrating fairly low NO_x stratification for a coal-fired unit.

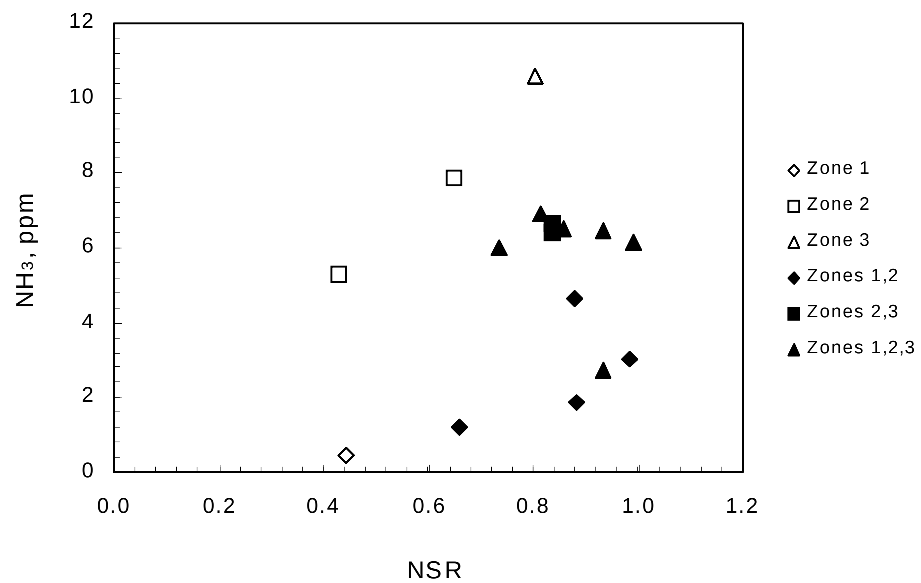


Figure 4-20
NH_3 Slip versus NSR, AEP Cardinal Unit 1, 450 MW

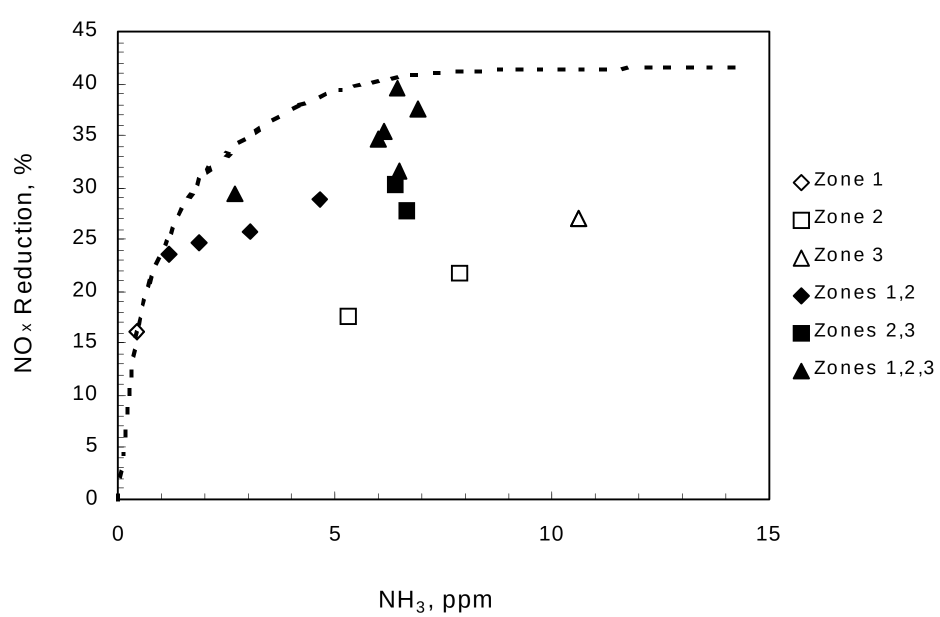


Figure 4-21
Relationship between NO_x Reduction and NH_3 Slip, AEP Cardinal Unit 1, 450 MW

Table 4-2
N_2O Emissions at 450 MW, AEP Cardinal Unit 1

Test No.	Load MW	Injection Levels In Service	Δ NO_x %	N_2O ppm	Δ N_2O/ΔNO_x %
184	457	1, 2, 3	31.5	21	16.6
186	457	1, 2, 3	37.6	21	14.6
191	450	1, 2	23.6	10	8.9
192	450	1, 2, 3	29.3	14	10.8

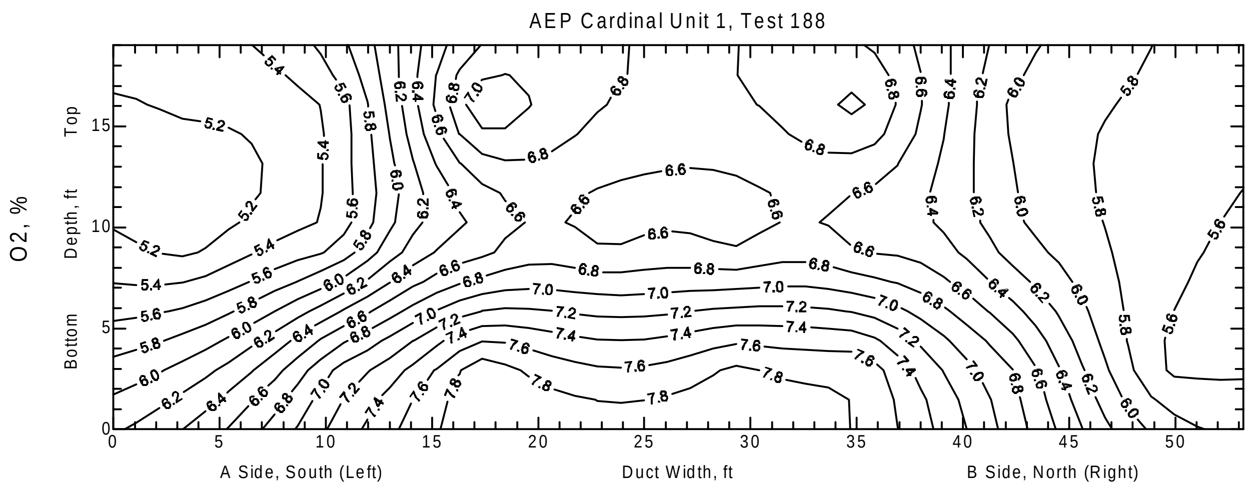


Figure 4-22
Baseline O_2 Contour Plot, AEP Cardinal Unit 1, 450 MW (Test 188)

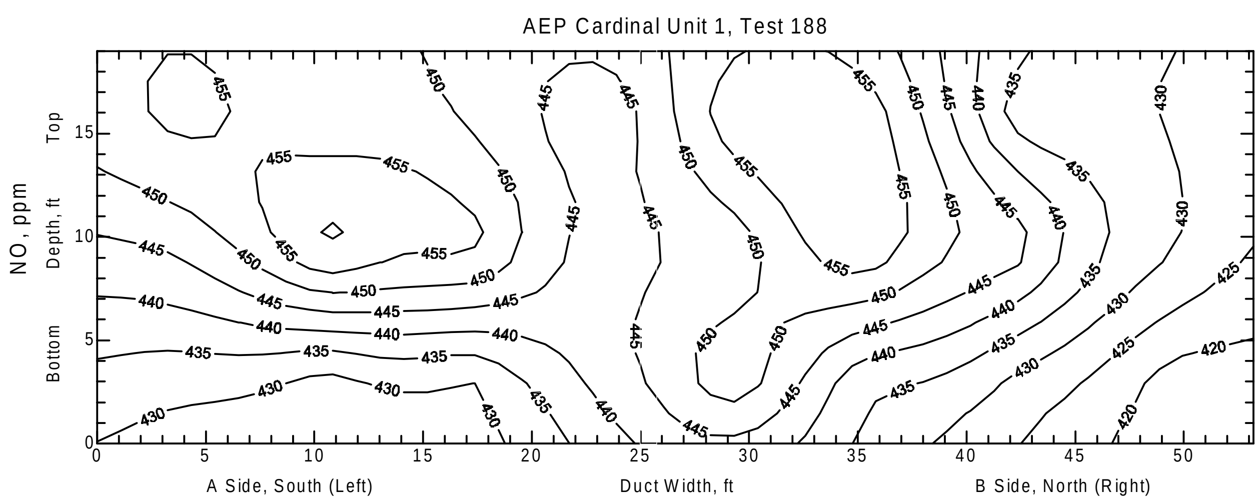


Figure 4-23
Baseline NO Contour Plot, AEP Cardinal Unit 1, 450 MW (Test 188)

The effect of Zone 1 injection using only the rear wall injectors is illustrated in Figure 4-24, where NO reduction profiles are shown for Test 190. NO reductions were significantly higher on the South side of the unit, reaching over 38 percent at the bottom of the duct. Peak reductions on the North side were only 24 percent, while reductions dropped to less than eight percent at the side wall. The reductions were nearly uniform from the top to the bottom of the duct.

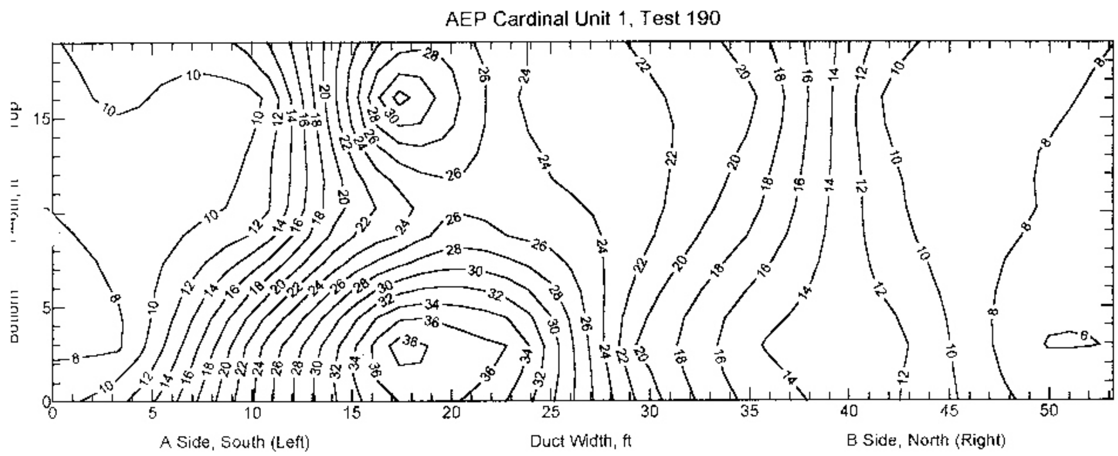


Figure 4-24
NO Reduction Contours Measured during Zone 1 Injection,
AEP Cardinal Unit 1, 450 MW (Test 190)

Figure 4-25 shows the NO reduction profiles for injection in Zones 1 and 2. The contours are similar to those seen when injecting in Zone 1 alone. Reductions are still higher on the South side, ranging from 10 to 44 percent. In comparison, reductions on the North side varied from 10 to 36 percent.

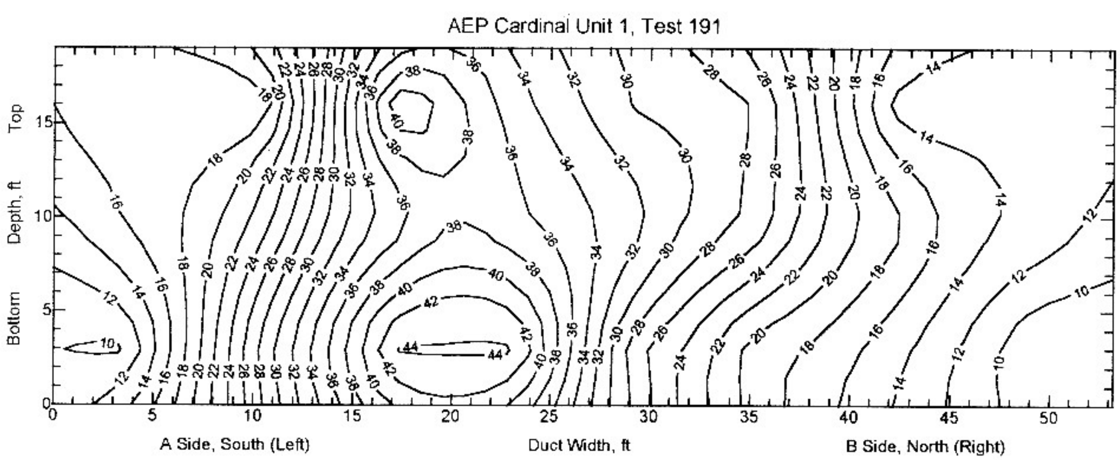


Figure 4-25
NO Reduction Contours Measured during Injection at Zones 1 and 2,
AEP Cardinal Unit 1, 450 MW (Test 191)

The effect of adding Zone 3 is illustrated in Figure 4-26 for Test 192. The NO reduction profiles still show a significant difference in performance between the South and North sides. NO_x reductions are still highest on the bottom of the South side, but the addition of the Zone 3 lances significantly increases NO_x removals on the North side of the duct.

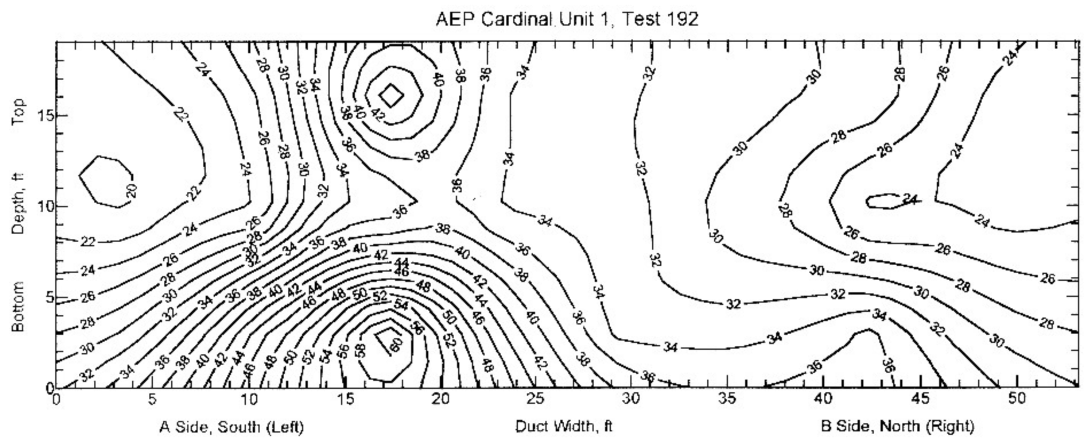


Figure 4-26
NO Reduction Contours Measured during Injection in Zones 1, 2 and 3, AEP Cardinal Unit 1, 450 MW (Test 192)

4.3 350-MW Test Results

Overview

The 350-MW tests were the minimum-load tests performed during this project. The minimum-load work included 29 tests run at loads between 340 and 370 MW. Appendix B summarizes the results of these tests.

Figure 4-27 shows NO_x reduction versus NSR for these minimum-load tests. Six injection combinations were evaluated as follows: Zone 1, Zone 2, Zone 3, Zones 1 and 2, Zones 1 and 3, and Zones 1, 2, and 3. When considering only a single injection level, the NO_x reduction performance at each level was nearly identical at a fixed NSR, up to NSRs of about 0.5. At higher NSRs, Zone 2 provided better NO_x reductions than Zone 1. Most of the work performed with multiple injection levels utilized Zones 1 and 2. At an NSR of 1.0, this injection scenario provided NO_x reductions of about 37 percent.

The corresponding NH_3 slip data are plotted versus load in Figure 4-28. At this load, NH_3 emissions were relatively high when injecting in Zone 3, approaching 10 ppm at a 0.4 NSR. In comparison, NH_3 slip values, when injecting in either Zone 1 or 2, were less than 4 ppm at a 0.4 NSR. When utilizing both Zones 1 and 2, NH_3 slip was less than 3 ppm at a 0.8 NSR. In comparison, injection using all three levels at an overall NSR of 0.8 resulted in NH_3 slip of almost 8 ppm.

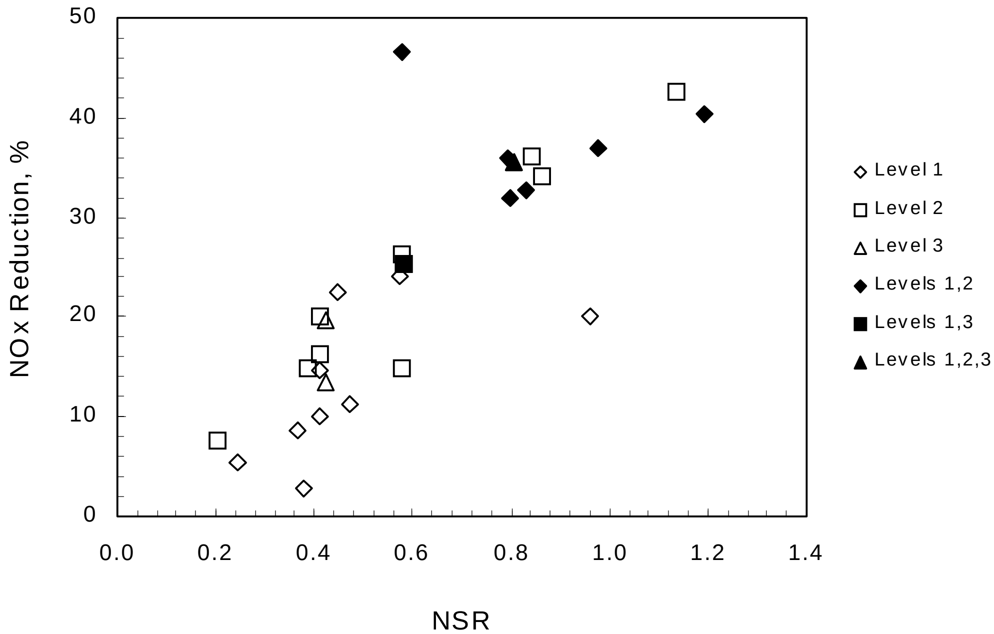


Figure 4-27
NO_x Reduction versus NSR, AEP Cardinal Unit 1, 350 MW

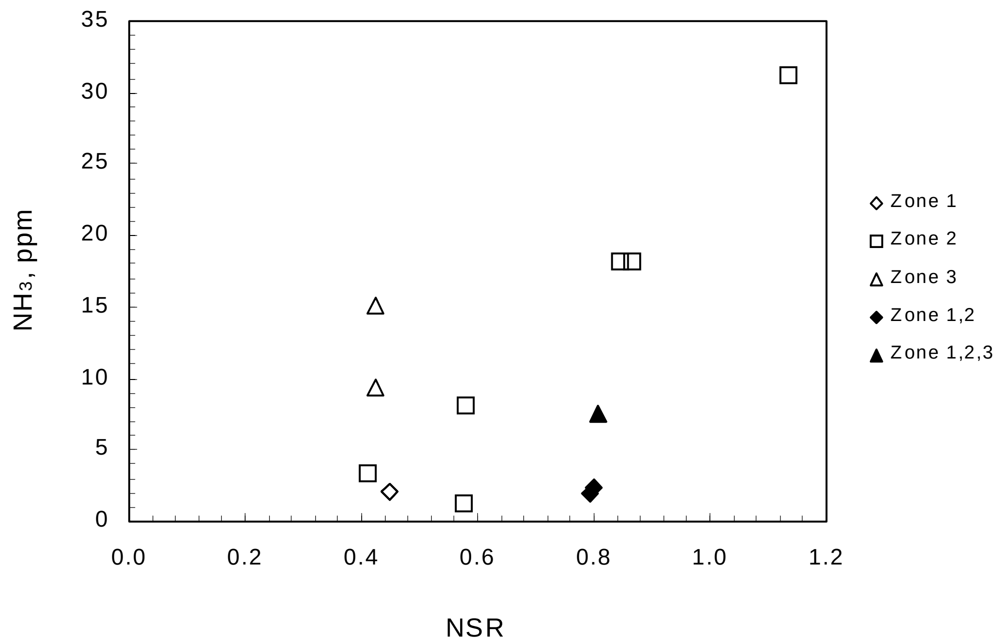


Figure 4-28
NH_3 Slip versus NSR, AEP Cardinal Unit 1, 350 MW

NO_x reductions are cross-plotted versus NH_3 slip in Figure 4-29 for the minimum load tests. NO_x reductions between 35 and 40 percent can be achieved at NH_3 slip levels below 5 ppm, using multi-zone injection. Again, the line in Figure 4-29 defines the upper bound of the performance measured during the optimization tests.

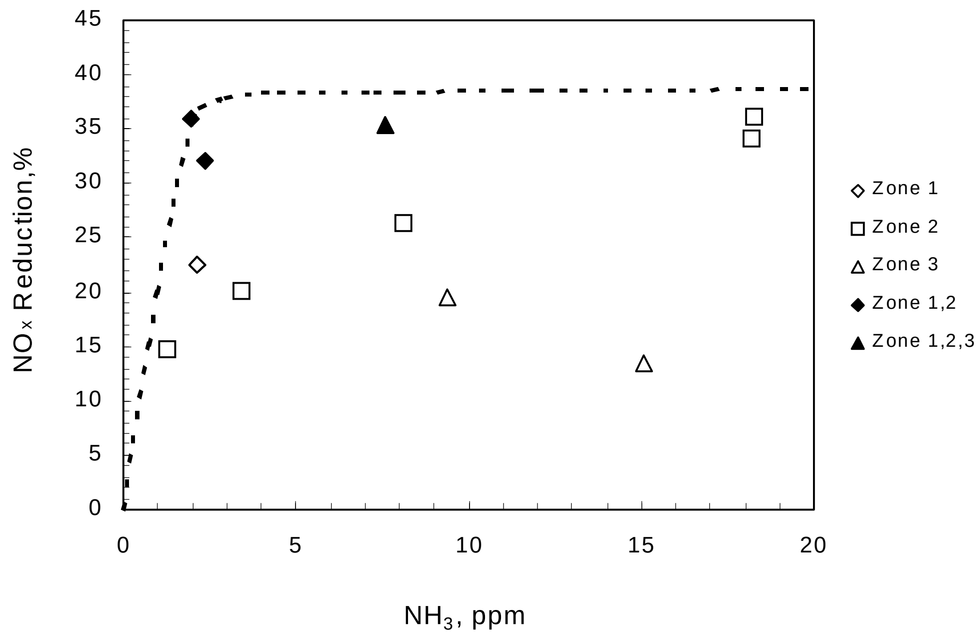


Figure 4-29
Relationship between NO_x Reduction and NH_3 Slip, AEP Cardinal Unit 1, 350 MW

Table 4-3 summarizes the N_2O emissions measured at 340 MW corresponding to the tests which define the upper bound in Figure 4-29. The $\Delta N_2O/\Delta NO_x$ ratio varied from 5.9 to 14.1 percent. The lower ratios at this load indicate that the injection may be occurring at higher-temperature regions of the furnace than those at higher loads.

Table 4-3
N_2O Emissions at 340 MW, AEP Cardinal Unit 1

Test No.	Load MW	Injection Levels In Service	ΔNO_x %	N_2O ppm	$\Delta N_2O/\Delta NO_x$ %
159	343	2	36.1	17	14.1
162	343	2	14.8	5	5.9
201	340	1, 2	36.0	15	11.1
202	340	1, 2	32.0	13	10.3
203	340	1, 2, 3	35.5	16	12.2

<u>Detailed Measurements at 350 MW</u>

Detailed measurements across the economizer exit grid were also made at the lower load of 350 MW. The baseline O_2 and NO_x concentration contours are shown in Figures 4-30 and 4-31. In general, there is a region of higher O_2 in the bottom central region of the duct, with lower O_2 regions on the two side walls. The NO_x contours are fairly uniform at this low-load condition, although the regions of higher NO_x correspond to the higher O_2 regions.

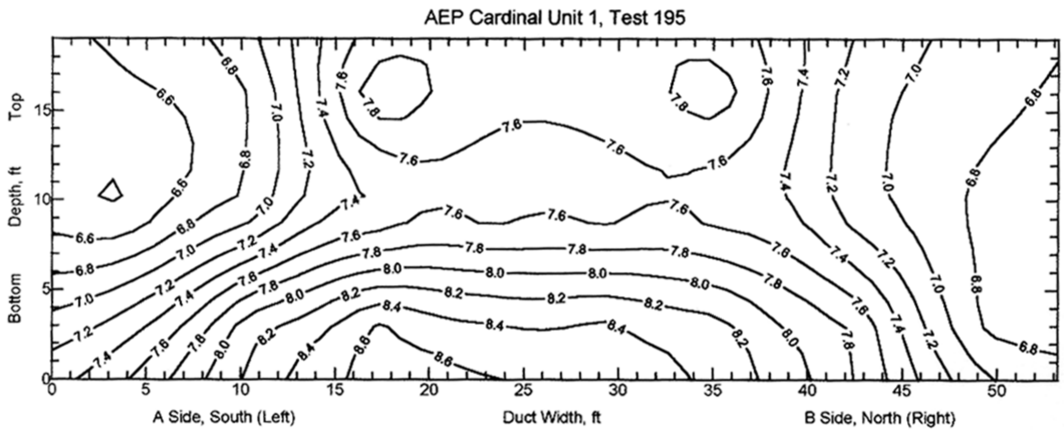


Figure 4-30
Baseline O_2 Contour Plot, AEP Cardinal Unit 1, 350 MW (Test 195)

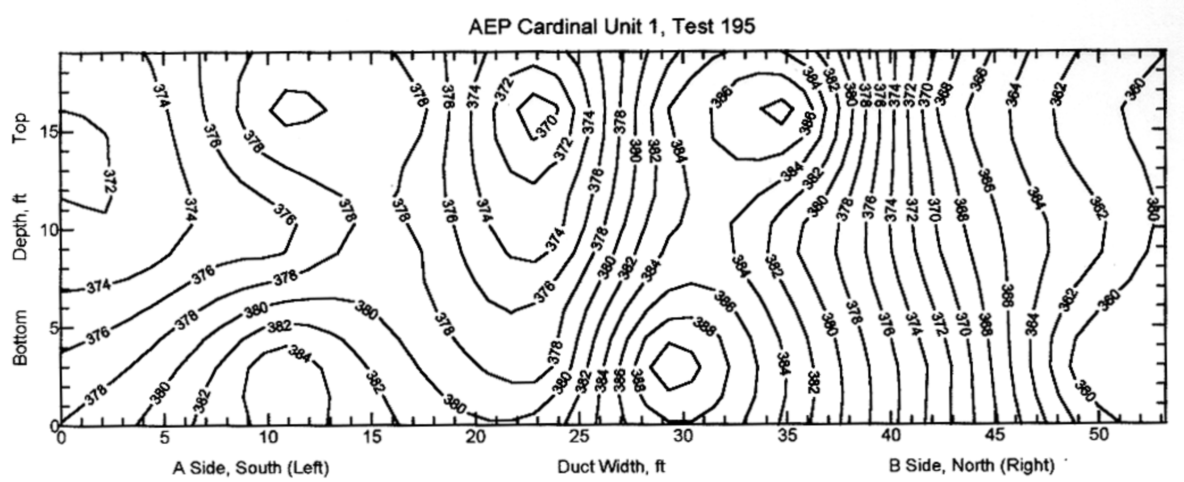


Figure 4-31
Baseline NO Contour Plot, AEP Cardinal Unit 1, 350 MW (Test 195)

Zone 1

Figure 4-32 shows the NO_x reduction contours with urea injected only through Zone 1 at a 0.57 NSR in Test 200. Recall that Zone 1 consists of wall injectors on all four sides of the furnace. The NO_x reductions are highest again at the bottom of the duct with the lowest removals at the outside walls.

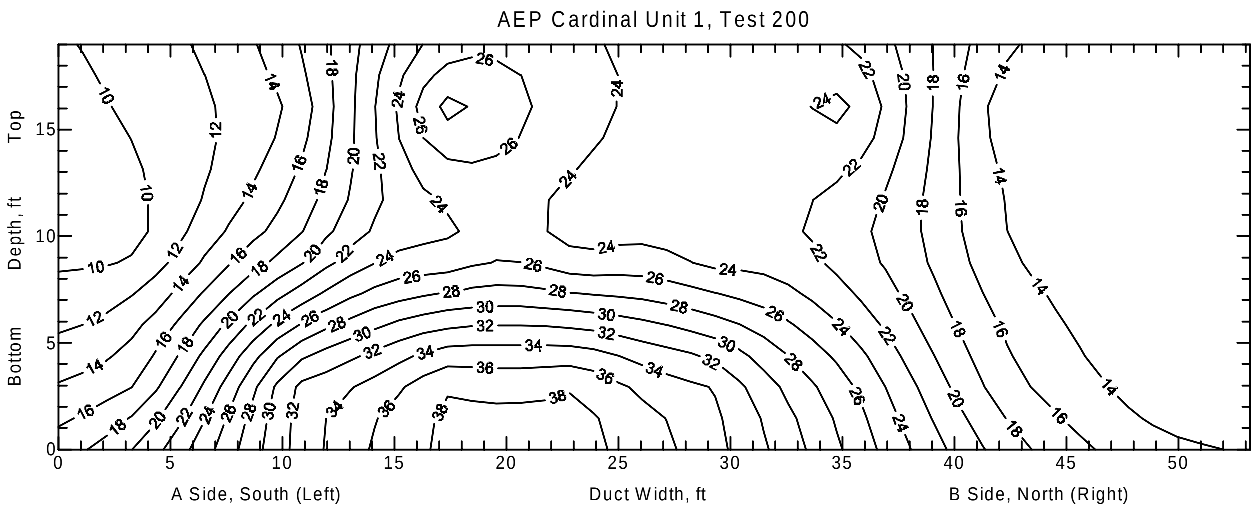


Figure 4-32
NO Reduction Profiles, Zone 1 Injection (Test 200)

Zones 1 and 2

Figure 4-33 shows the NO_x reduction contours when both Zones 1 and 2 are utilized with a 0.79 NSR in Test 201. In the test, the Zone 1 conditions were the same as Test 200, while additional urea was injected through Zone 2, resulting in a higher overall NSR. In general, the NO_x reduction contours are similar, although there appears to be a little higher reduction occurring on the top of the duct relative to the bottom.

Zones 1, 2 and 3

Figure 4-34 for Test 203 shows the NO_x reduction contours at an NSR of 0.81 with injection through all three zones. Compared to injection through Zone 1 or Zones 1 and 2, using all three zones results in a more uniform distribution of NO_x reduction from North to South, although it is still biased toward the bottom of the duct. For this test, the overall NO_x reduction was 36 percent with ammonia slip of 8 ppm.

During the optimization tests, obtaining these detailed NO_x reduction contours at the economizer exit provided insight to the test team in assessing the injection scenarios.

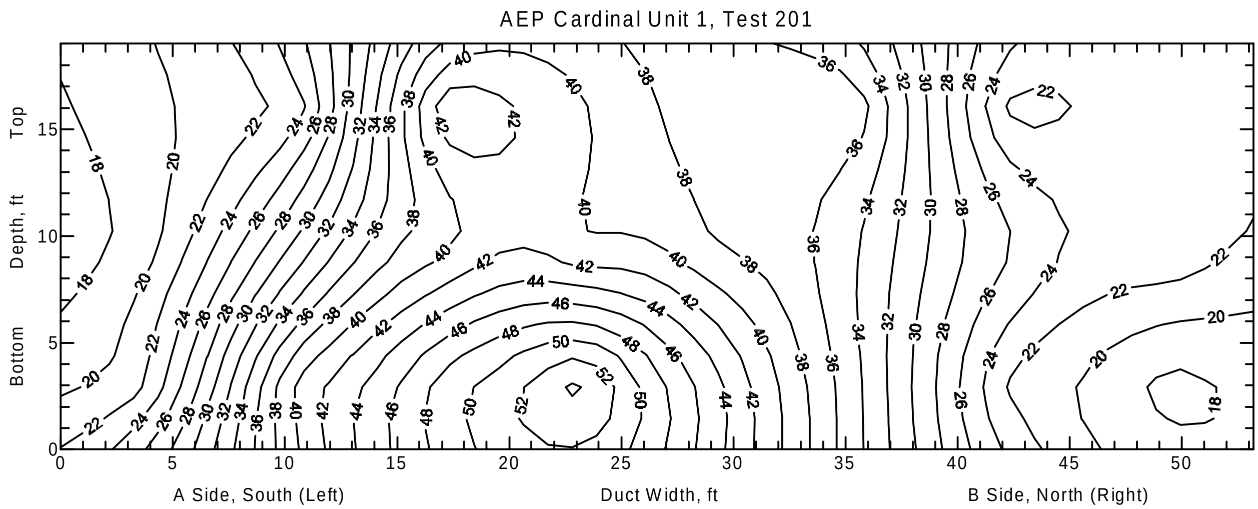


Figure 4-33
NO Reduction Profiles, Zones 1 and 2 Injection (Test 201)

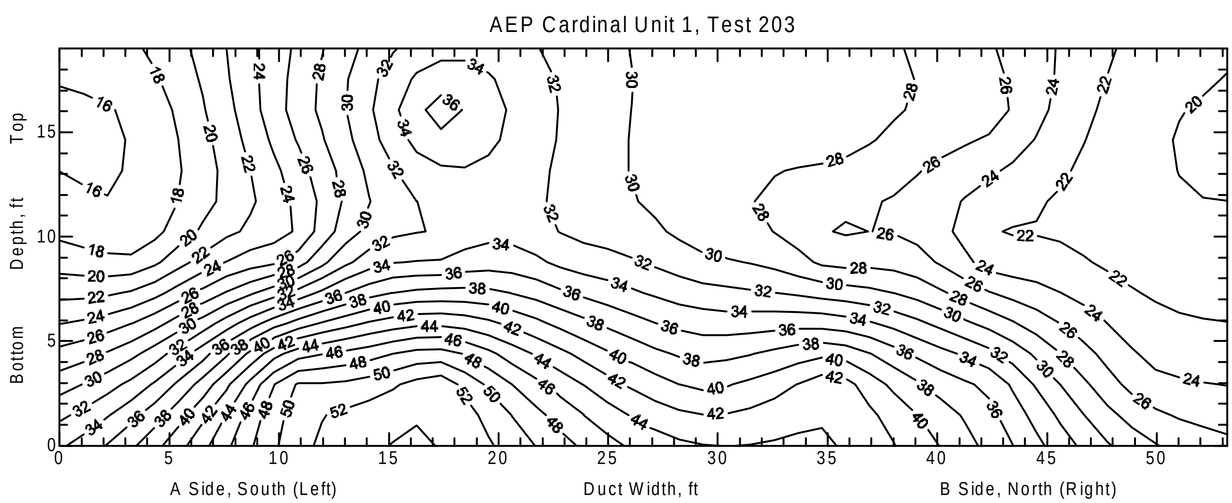


Figure 4-34
NO Reductions, Zones 1, 2 and 3 Injection (Test 203)

4.4 Optimization Test Summary

The optimization tests were conducted at three major loads – 600, 450 and 350 MW – with limited tests at other intermediate load points. The tests comprised a wide variety of variations covering the zones in service, injectors in service at each zone, chemical bias, the amount of urea injected, and other injection parameters.

As a result of the optimization tests, the following performance was documented for NH_3 slip levels less than 5 ppm, based on the lines defining the upper bounds in Figures 4-4, 4-21, and 4-29:

600 MW: up to 32% NO_x reduction
450 MW: up to 38% NO_x reduction
350 MW: up to 38% NO_x reduction

At full load the optimum performance was achieved with Zones 2 and 3. At intermediate load the optimum performance was found with Zones 1, 2 and 3, while Zones 1 and 2 provided the optimum performance for the low-load condition.

While determining the preferred injection scenarios at the three main load conditions was an important part of the optimization, equally as important was determining the transition points at which zones are put in or taken out of service. In particular, it was important to determine at which load Zone 1 injectors could be used effectively and the point at which the lances in Zone 3 should be removed from service. The rear wall injectors in Zone 1 were found to be most effective below 500 MW, the remainder of Zone 1 was inserted below 410 MW. The optimization tests also showed that Zone 3 should be removed below 410 MW.

5
LONG-TERM TEST RESULTS

The goal of the long-term demonstration portion of the test program was to verify the performance of the SNCR system during automatic operation, while the boiler is under normal load dispatch, including the documentation of any balance-of-plant impacts. The long-term demonstration comprised two activities: 1) a week of final tuning to allow Fuel Tech to verify the system settings selected for the long-term operation, and 2) nominally six weeks of long-term testing.

5.1 Automatic Control Scheme

Before presenting the long-term results, a short discussion on SNCR system controls is warranted. During the optimization test phase, tests were conducted at steady loads to determine optimum SNCR operating parameters. As discussed in Section 4, this involved starting with the SNCR system off in order to obtain a baseline NO_x level. Then the SNCR system was turned on, determining the NO_x level achieved. After the SNCR system was turned off and the baseline NO_x level checked, the NO_x reduction was then calculated using the baseline NO_x level and the NO_x level with the SNCR system on.

With the SNCR system in automatic operation a baseline NO_x level is not available. As a result, controlling to a given percentage NO_x reduction is not possible. Instead, the SNCR control scheme uses a prescribed set of SNCR parameters versus load, based on the results of the optimization tests, to achieve a target outlet NO_x level. The feed-forward controls can then be modified using various trim signals (e.g., Spectratemp temperature measurements and CEM NO_x vs. target NO_x).

As a consequence, NO_x reduction can only be calculated after the fact using NO_x levels measured either before the SNCR system is put in automatic operation or after the long-term testing is completed.

Based on the data from the optimization tests, Fuel Tech selected SNCR parameters that would achieve NO_x levels of 0.49 lb/MMBtu (359 ppm @ 3% O_2) at full load and 0.36 lb/MMBtu (264 ppm @ 3% O_2) at reduced loads. The full-load target of 0.49 lb/MMBtu represents a 30% reduction from an assumed baseline NO_x level of 0.70 lb/MMBtu (513 ppm @ 3% O_2). The lower-load target of 0.36 lb/MMBtu (264 ppm @ 3% O_2) represents a 36% reduction from an assumed baseline of 0.56 lb/MMBtu (411 ppm @ 3% O_2).

Again, as the long-term data presented below are reviewed, keep in mind that the SNCR control is primarily feed forward with feedback trim signals designed to achieve a target NO_x level in lb/MMBtu, and not the percentage NO_x reduction. The NO_x reduction is a quantity calculated after the fact. Thus, changes in boiler operations that influence baseline NO_x can result in a change in the calculated NO_x reduction.

5.2 Test Procedures

The long-term testing included manual tests performed at fixed loads in conjunction with monitoring of SNCR system operation during normal system dispatch conditions. The fixed-load tests required two to three hours of steady load per day. These tests, performed five days per week, were included to provide an opportunity to perform wet chemical NH_3 measurements while the unit was at a constant load. During all of the testing, the SNCR system was in automatic operation, and no parameters were changed by the test personnel.

The daily schedule for the long-term testing involved making ammonia measurements using manual traverse methods at the fixed load. During the initial tests, gaseous emissions profiles were also obtained. Once these tests were complete, the unit was released to the system dispatcher. Daily CEM reports were gathered, and the data logged in a weekly summary spreadsheet. A hopper ash sample was taken and prepared for analysis. The day's ammonia samples were analyzed along with the previous day's ash sample. Control room data were taken at nominal two-hour intervals. Informal weekly reports were prepared for funders of the project. Appendix C contains a summary of the long-term data.

5.3 Long-term Overview

The long-term testing began on September 27 and continued through November 19, 1999. Table 5-1 summarizes the primary activities during this time. This period comprised about 1270 hours. The SNCR system was on line for about 960 hours of this time. Most of the downtime can be attributed to a period of nominally 240 hours when the unit was off line. About 241,000 gallons of urea were used during the demonstration.

At the completion of the testing, the CEM data were sorted to determine the time spent at different loads. To do this, the load range of 300 to 620 MW was divided into 10 equal bins of 32 MW each. The number of occurrences in each load bin was divided by the total number of occurrences to give the percentage of time in each bin. These results are shown in Figure 5-1. The unit spent nearly 15 percent of this time operating in the 316-MW load bin and about 55 percent of the time operating in the 348-MW load bin. Thus, only about 30 percent of the time was spent at loads of 364 MW and higher.

Automatic operation of the SNCR system began on September 28, midway through the week of final optimization. The system began fully automatic operation on the afternoon of October 1. During the following weekend, the pumps were inadvertently shut down by plant personnel switching electrical breakers at about 16:15 Sunday. The pumps were reset, and the system was back in operation by 10:20 Monday. During the week of October 11, the rotameter for the 1T injector on the rear wall of Zone 1 developed a leak and was shut down.

Table 5-1
Summary of Primary Activities

Week of:	Activity
September 20	Equipment set-up SO_3 measurements
September 27	Final Fuel Tech optimization
October 4	Long-term testing
October 11	Long-term testing Unit off-line starting October 15
October 18	Unit off-line
October 25	Long-term testing
November 1	Long-term testing
November 8	Long-term testing
November 15	Long-term testing completed November 19

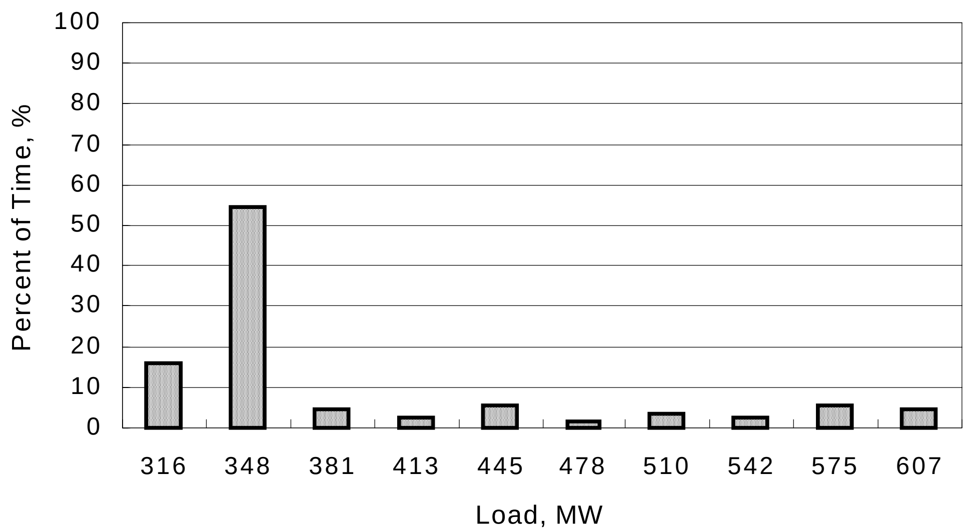


Figure 5-1
Load Duration History

The boiler was taken off line October 14 after the evening peak and returned to service on October 24, 1999. After the unit's restart, one section from each of the 3C and 3E MNLs was taken out of service due to leaks. Each lance has three sections, and with two sections out of service, the coverage was reduced by about 17 percent. The leaks were subsequently traced to cracked welds. Both the 3C and 3E MNLs were taken out of service on October 28 to repair the leaks. The 3C MNL was placed back in service by the end of the day. Although the 3E MNL required one more day of work, it was still not repaired by the end of the week. Rather, it was placed back in service with two of its three zones operational. MNL 3E was subsequently repaired during the following week. The 1T injector was also placed back in service during this week. The SNCR system was off line at the beginning of the week. The problem was again traced to a loss of power caused by plant personnel switching breakers. The system was back on line before noon Monday. It was also noted that three burner lines were out of service due to blockages. This resulted in six burners being taken out of service. These burners remained out of service for the remainder of the long-term testing.

During the week of November 1, the 3E MNL was out of service for two days. It was repaired during this time and placed back in service on November 5, 1999. The SNCR system was off line for slightly less than two hours on November 9, when it shut down due to low flow. The problem was determined to be high strainer pressure differential. The original (North) strainer was cleaned, and the system switched to the second (South) strainer. The SNCR system was then placed back in service.

5.4 Test Results

5.4.1 NO_x Emissions

As discussed above, the SNCR system controls to an outlet NO_x setpoint, and the percentage NO_x reductions are calculated after the fact. The baseline NO_x value is obtained either by turning off the urea, or by using a baseline NO_x level from a time period when the urea system was not in service. At the outset of the project, the plan was to use the CEM data collected during the third quarter of 1999 as the baseline NO_x levels to be used in calculating percentage NO_x reductions from the SNCR system. However, this was not possible because the unit burned a lower-sulfur coal for the majority of this period. The NO_x levels were found to be higher across the load range with the low-sulfur coal compared to the high-sulfur coal burned during the optimization and long-term tests of the SNCR system.

Figure 5-2 shows the SO_2 emissions versus time for the third quarter of 1999. With the exception of two time periods during that quarter, the unit was burning a lower-sulfur coal.

The CEM NO_x data for the third quarter of 1999 were sorted by SO_2 levels. NO_x emissions associated with SO_2 emissions greater than 1,900 ppm were considered high-sulfur data, and those with SO_2 emissions less than 1,100 ppm were considered low-sulfur data. SO_2 emissions between 1,100 and 1,900 ppm were considered to be a result of a coal blend, and the associated NO_x emissions were not included. Figure 5-3 shows the NO_x emissions attributed to the two coal types fired during the third quarter of 1999. The NO_x emissions associated with the low-sulfur coal were between 0.10 and 0.15 lb/MMBtu (73 and 110 ppm @ 3% O_2) higher than those measured when firing the high-sulfur coal. For this reason, the NO_x emissions obtained when firing low-sulfur coal during the third quarter of 1999 could not be used as the baseline for the long-term demonstration.

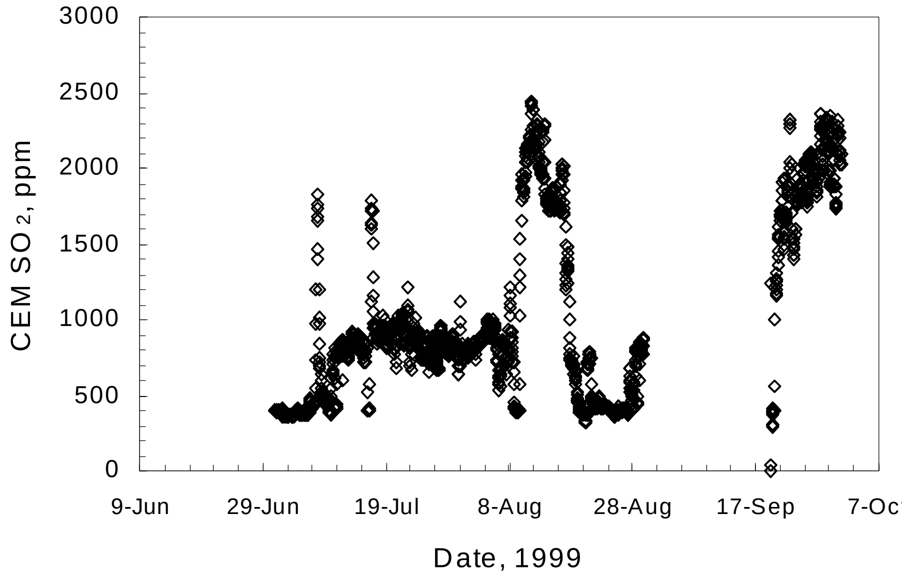


Figure 5-2
SO_2 Emissions versus Time, AEP Cardinal Unit 1, Third Quarter 1999

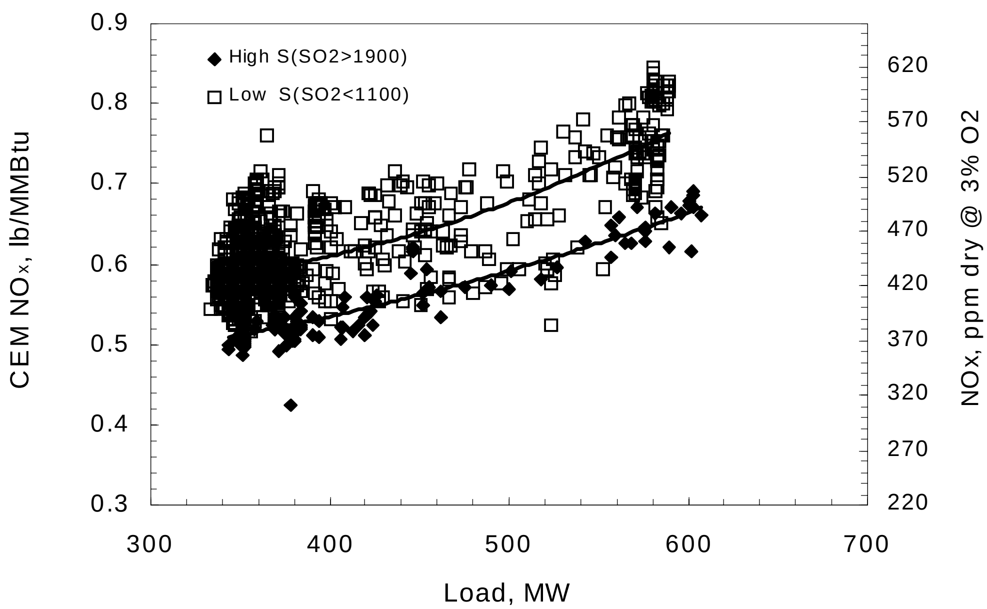


Figure 5-3
NO_x Emissions versus Load for High- and Low-Sulfur Coal,
AEP Cardinal Unit 1, Third Quarter 1999

In order to establish a high-sulfur baseline NO_x data set, CEM data for the following periods were used.

Post Retrofit: (12/98-3/99)	CEM NO_x data following startup and optimization of the low-NO_x burners, but prior to the SNCR tests
Optimization: (3/99-4/99)	CEM NO_x data taken during the SNCR optimization tests when the urea was turned off
Pre Long-term: (5-99-9/99)	CEM NO_x data for the summer of 1999 prior to the long-term tests when the unit was burning high-sulfur coal
Long-term: (9/99-11/99)	CEM NO_x data for the short periods during the long-term tests when the urea was turned off

Figure 5-4 shows the scatter plots of these CEM data sets versus load, and Figure 5-5 shows the curve fits through the individual sets of data.

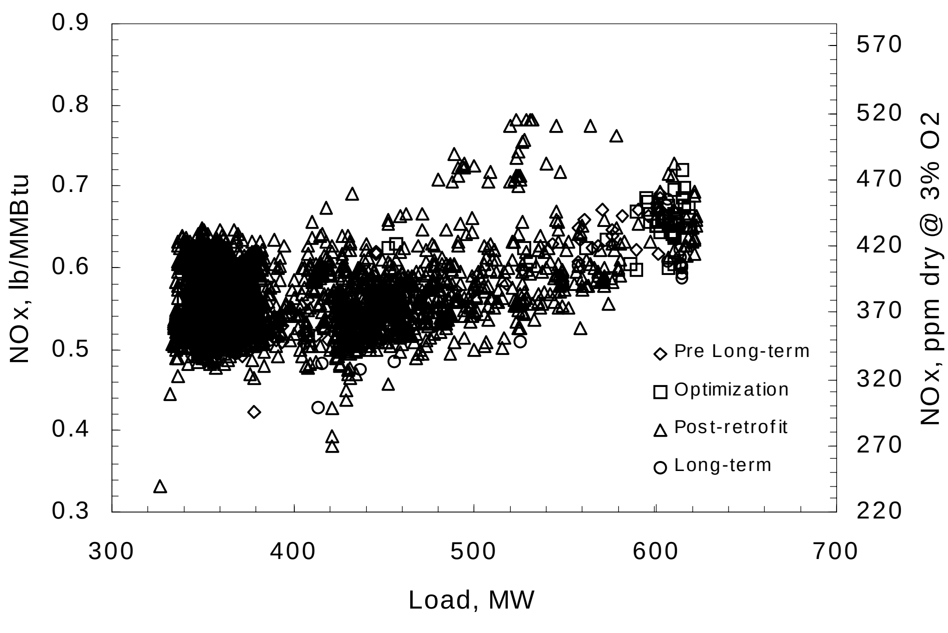


Figure 5-4
Baseline CEM NO_x Emissions Data, High-Sulfur Coal

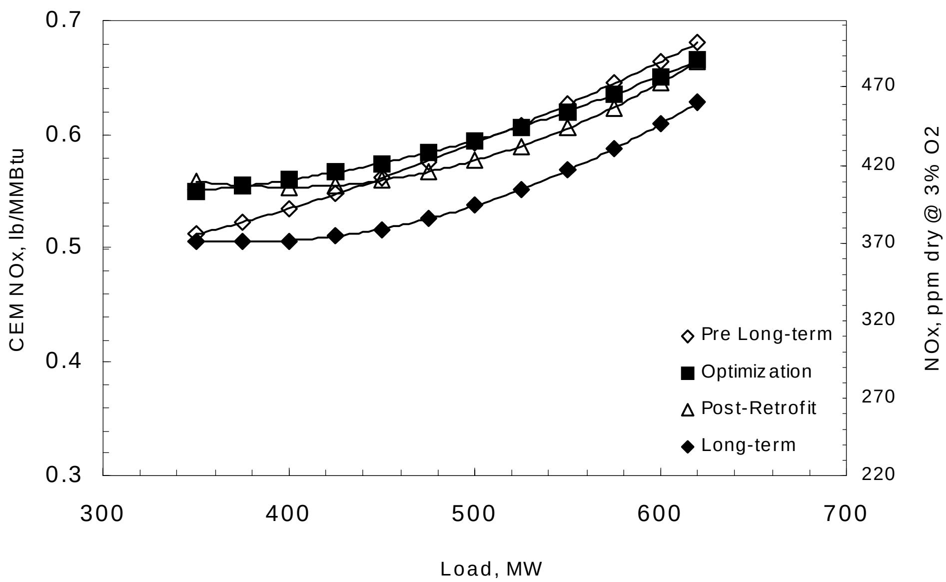


Figure 5-5
Comparison of Baseline NO_x Emissions when Firing High-Sulfur Coal, AEP Cardinal Unit 1

Next, the average of these four data sets was determined. First, all of the data were combined, and a curve fit of the data group as a whole was made, shown in Figure 5-6 as the Point Average. Note that this approach gives more weight to the data sets containing more readings. Next, the average of the four individual curve fits shown in Figure 5-5 was made. This curve, labeled Unweighted Average, counts each of the four data sets equally. The curves are virtually identical at loads above 450 MW, while the Point Average provides slightly higher NO_x emissions at the lowest loads. The Unweighted Average line was used to calculate the NO_x reductions for the long-term tests.

Figure 5-7 shows NO_x emissions plotted versus load for the baseline and long-term SNCR test periods. The data scatter in this figure illustrate normal variations in NO_x emissions due to changes in operating conditions. Figure 5-8 shows the corresponding curve fits for these data sets. Average NO_x reductions varied from 25 percent at full load to 30 percent at 350 MW for the long-term testing. These results compare to average reductions of 32 percent at full load to 38 percent at 350 MW during the optimization testing.

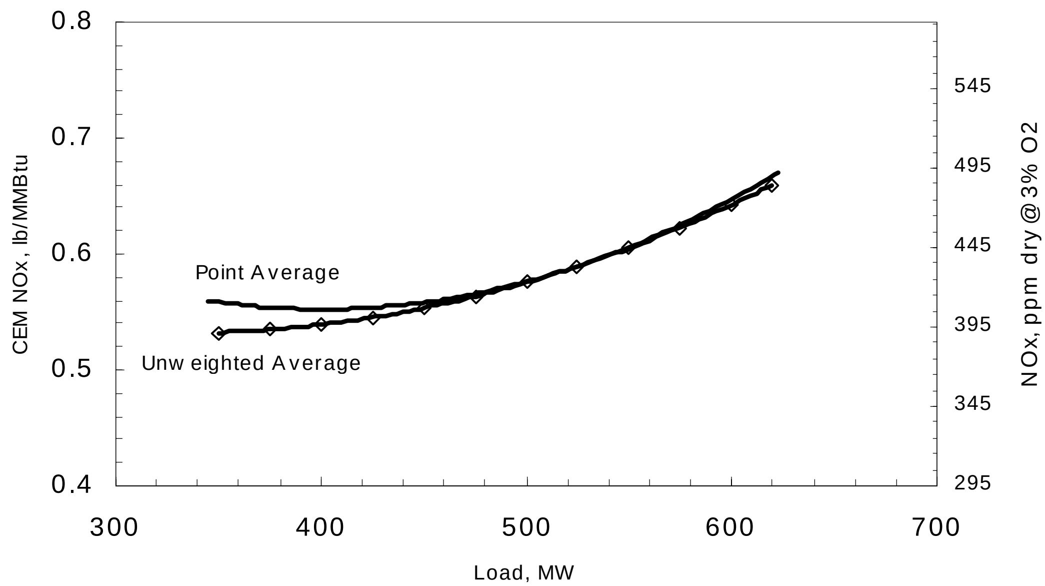


Figure 5-6
Comparison of Average Baseline NO_x Emissions Curves, AEP Cardinal Unit 1

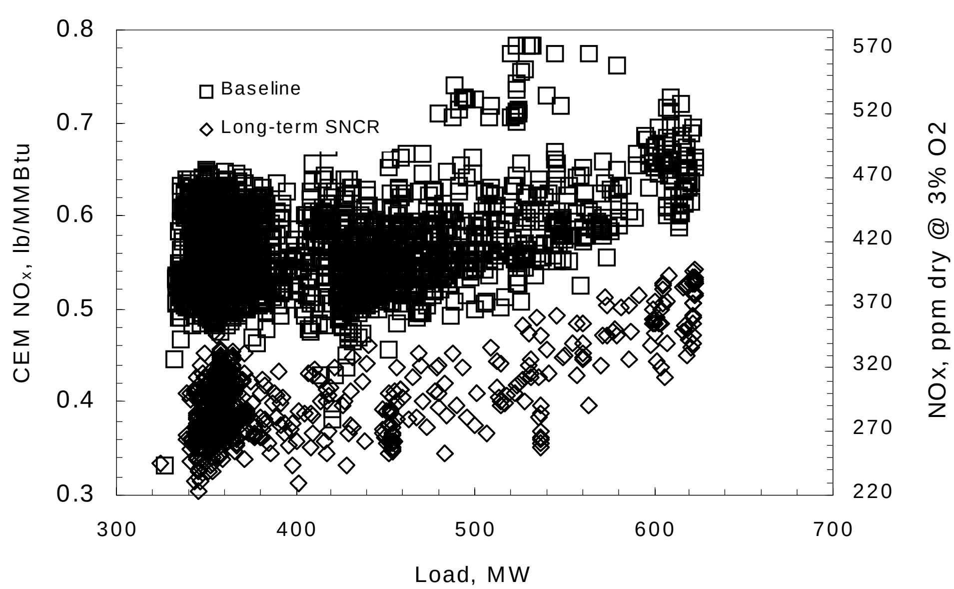


Figure 5-7
Baseline and Long-term SNCR CEM NO_x Emissions

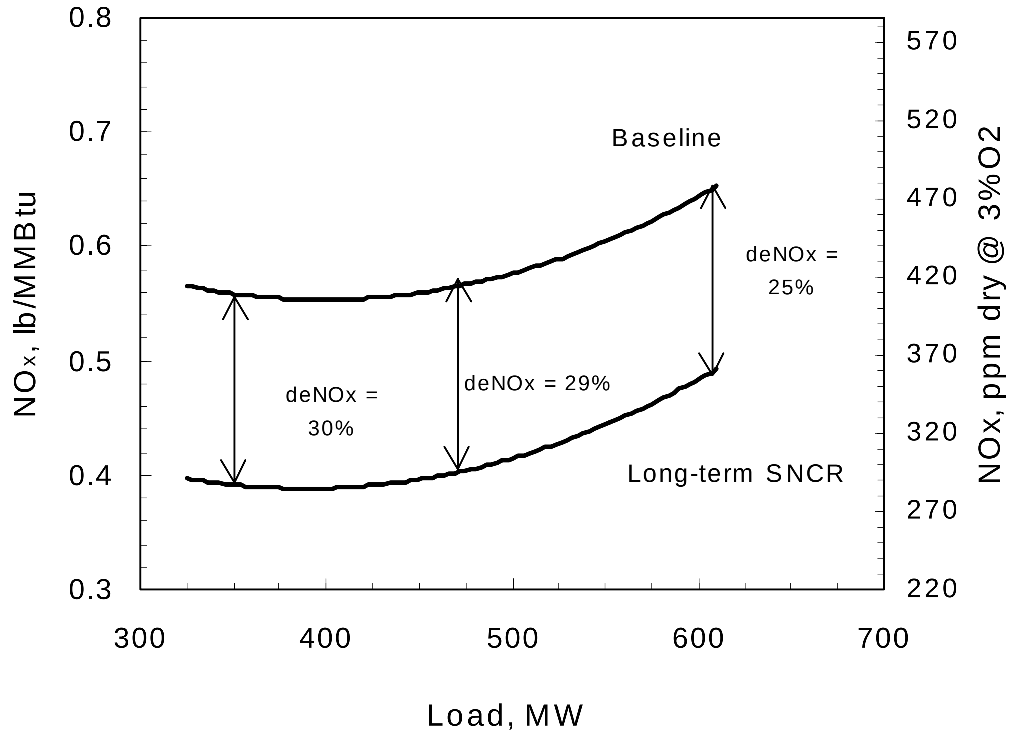


Figure 5-8
Curve Fits of the Baseline and Long-term CEM NO_x Emissions Data

As discussed previously, the SNCR control system uses load to determine the injection levels that should be in service and the target urea flow rate. The controls then compare the outlet NO_x value to the target and adjust the urea flow rate accordingly. Recall that at full load, the control system was set up to achieve a target NO_x level of 0.49 lb/MMBtu (359 ppm @ 3% O_2) which represented a thirty percent reduction from a baseline NO_x level of 0.70 lb/MMBtu (513 ppm @ 3% O_2). Since the full-load baseline NO_x level of 0.66 lb/MMBtu (484 ppm @ 3% O_2) was lower, the SNCR system only needed to operated at a 25% NO_x reduction level to achieve the target NO_x. Had the baseline NO_x levels been higher, it is reasonable to assume that higher NO_x reductions, as demonstrated during the optimization tests, would have been achieved.

Figure 5-9 shows the NO_x levels that Fuel Tech targeted for the long-term testing at three different loads. Also shown are the average NO_x emissions from the long-term testing at these three load points. The Fuel Tech NO_x targets for the long-term testing were 0.49 lb/MMBtu (359 ppm @ 3% O_2) at full load and 0.36 lb/MMBtu (264 ppm @ 3% O_2) at reduced loads. These represent reductions of about 30% at full load and 36 percent at reduced loads. Full-load NO_x emissions averaged 0.51 lb/MMBtu (374 ppm @ 3% O_2) during the long-term testing while the SNCR system was in service, comparing favorably with the 0.49 lb/MMBtu (359 ppm @ 3% O_2) target. At reduced loads, the NO_x emissions averaged 0.39 lb/MMBtu (286 ppm @ 3% O_2) at

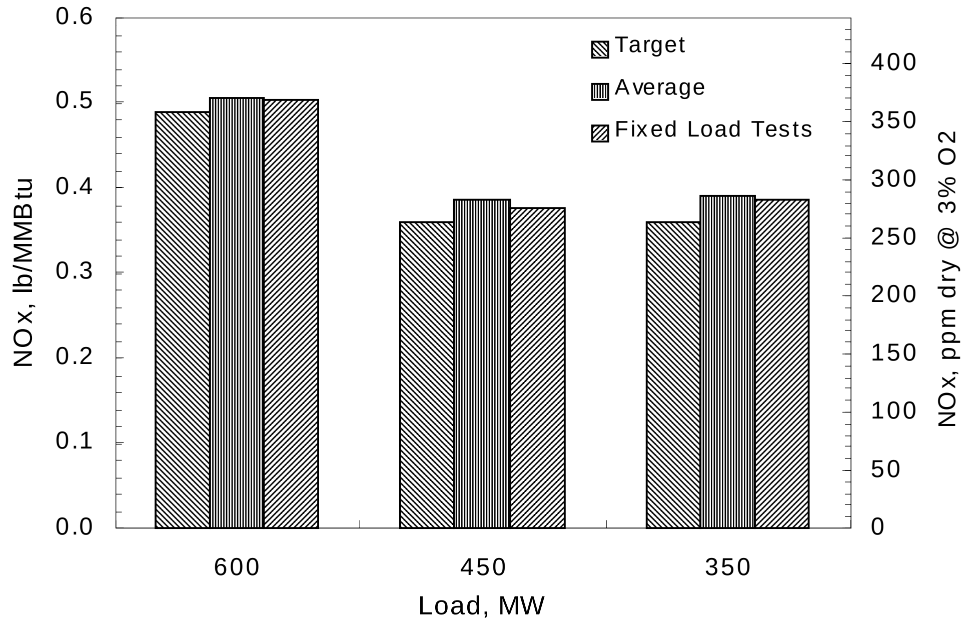


Figure 5-9
Comparison of Target and Average NO_x Emissions during Long-term Testing

both 450 and 350 MW, slightly higher than the target. These data show that the SNCR system was able to provide NO_x emissions within ten percent of the desired target across the load range under normal load-following conditions.

In order to see the effects of load following versus steady-load operation, data from periods when the load was steady during the long-term tests have also been included in Figure 5-9. The corresponding scatter plot of the fixed-load data is shown in Figure 5-10. These data exhibit much less scatter than the full data set, as expected, because these fixed-load data were not subject to transient influences that other data gathered during the long-term testing may have been. The average NO_x emissions at 600, 450, and 350 MW were 0.50, 0.38, and 0.39 lb/MMBtu (367, 279, and 286 ppm @ 3% O_2), respectively, slightly lower than the averages obtained from the entire data set.

5.4.2 NH_3 Slip

Figure 5-11 shows ammonia emissions plotted versus load using data from the manual tests performed at fixed loads. The data show that measured ammonia emissions were generally below 5 ppm over the duration of the long-term testing. Concentrations greater than 5 ppm sometimes occurred when off-design conditions were encountered. For example, high slip was measured at 533 MW when operating with one mill out of service. Also, three tests were performed at 600 MW and higher when two of the MNLs were out of service, resulting in higher flows to the remaining MNLs than desired, and correspondingly higher NH_3 slip levels.

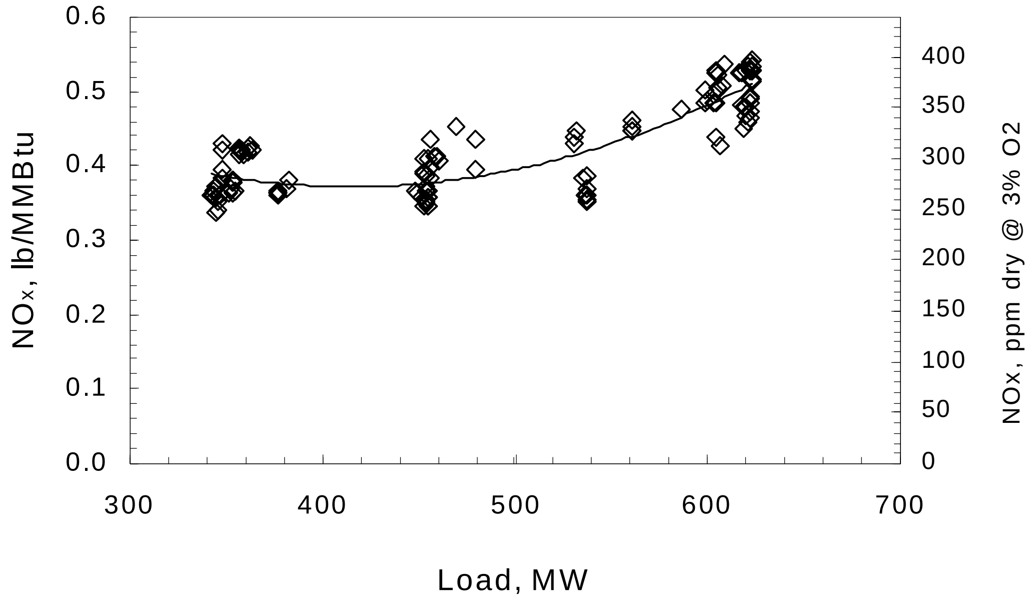


Figure 5-10
CEM NO_x Emissions versus Load, Fixed-Load Tests

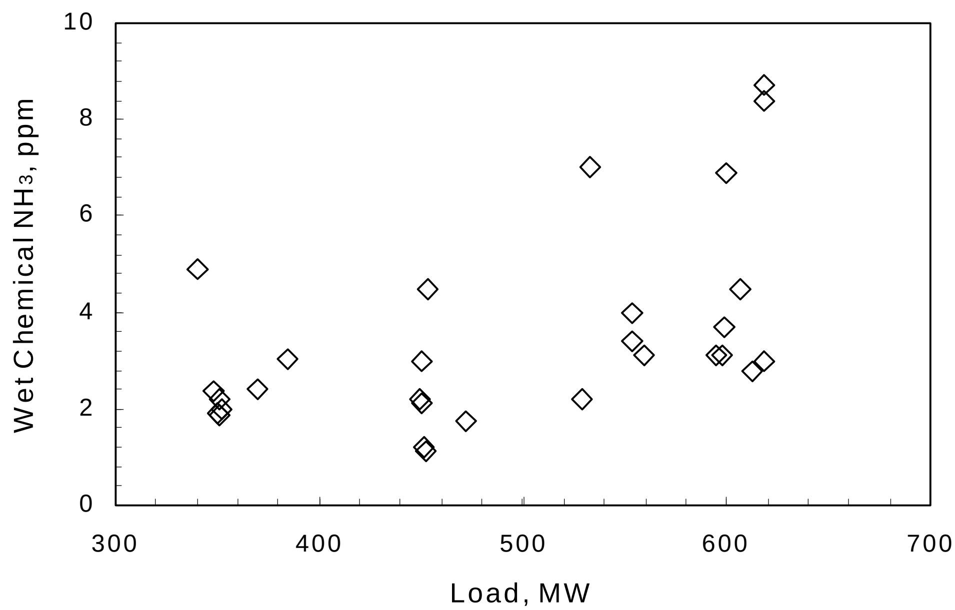


Figure 5-11
NH_3 vs. Load, Long-term Testing

Near the end of the long-term testing, a series of ammonia tests was performed on Cardinal Unit 1 at three locations to determine the fate of ammonia slip through the unit. These sample locations included the economizer exit, APH exit and ESP exit. All of the samples were taken from the North side of the unit. The tests were performed with the unit operating at full load and the SNCR system operating in automatic. Table 5-2 summarizes the results of these tests.

Table 5-2
Ammonia Concentrations at Three Sample Locations

Date, 1999	Test No.	Sample Location	NH_3 Concentration, ppm	Comments
Nov 16	141	APH In	2.5	No probe filter
		APH Out	0.48	No probe filter
		ESP Out	0.22	No probe filter
	142	APH In	2.8	No probe filter
		APH Out	0.14	Probe filter
		ESP Out	0.14	Probe filter
	143	APH In	2.3	No probe filter
		APH Out	0.05	Probe filter
		ESP Out	0.04	Probe filter
	144	APH In	2.3	No probe filter
		APH Out	0.05	Probe filter
		ESP Out	0.03	Probe filter

Four NH_3 samples were taken at each location. The NH_3 sampling and analysis methods have been described previously. The first set of samples at the APH and ESP exit locations were made with no filter plug on the probe, providing a total ammonia concentration, including both gas-phase and solid ammonia. The following three samples at the APH and ESP exit locations were taken using a filter plug at the probe inlet, thus measuring only gas-phase ammonia. Samples at the economizer exit were taken with no filter plug, as had been the case for the entire SNCR program. At the economizer exit temperatures, the NH_3 should be entirely in the gas phase.

Figure 5-12 shows the relationship between the total ammonia concentrations measured at the three sample locations during the first run. Total ammonia is defined as gas-phase NH_3 plus condensed NH_3 (referred to as ammonium). Ammonium can include ammonia condensed on fly ash and ammonium-sulfur compounds, such as ammonium sulfate and ammonium bisulfate. The total NH_3 at the economizer exit was 2.5 ppm, compared to 0.5 ppm and 0.2 ppm at the APH, and ESP exit, respectively. This indicates that about 80 percent of the total NH_3 dropped out across the APH, and 60 percent of the remaining NH_3 dropped out in the ash collected in the ESP.

Figure 5-13 shows the results of the remaining three runs where only gas-phase NH_3 was measured. Gas-phase NH_3 levels averaged 2.5, 0.08, and 0.04 ppm at the economizer exit, APH exit and ESP exit sample locations, respectively. About 96 percent of the gas-phase NH_3 was converted to a solid form or dropped out across the APH, and 50 percent of the remaining gas-phase NH_3 was again converted to a solid form or dropped out in the ash collected by the ESP. Figure 5-14 shows the relationship between gas-phase ammonia and condensed ammonia (ammonium) at the APH and ESP outlets. Just over 80 percent of the total NH_3 was in the condensed phase at both the APH and ESP exit sample locations.

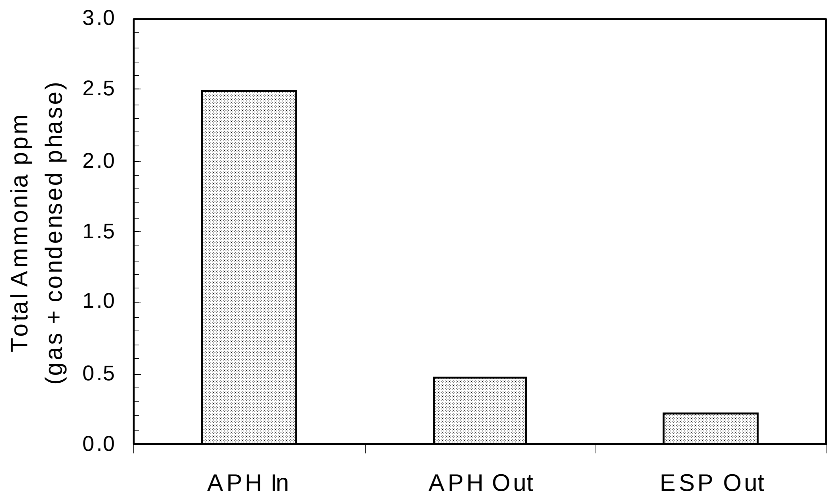


Figure 5-12
Total Ammonia at Three Sample Locations

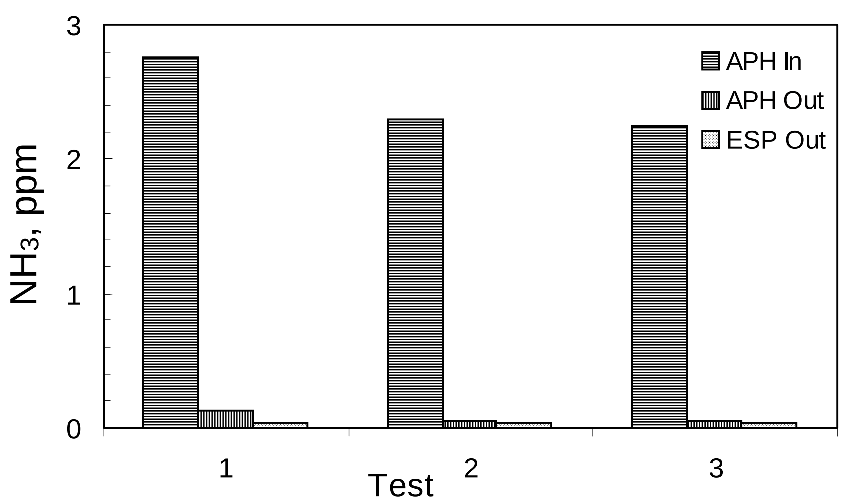


Figure 5-13
Gas-Phase Ammonia at Three Sample Locations

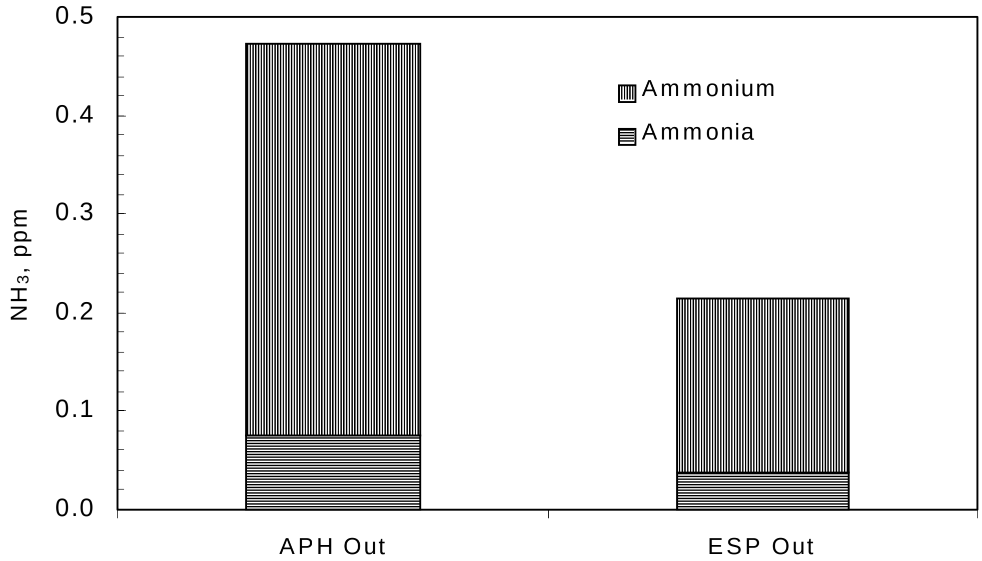


Figure 5-14
Relationship between Gas-Phase and Condensed Ammonia at APH Exit and ESP Exit

5.4.3 Ash NH_3

Daily ash samples were taken from hopper 1-4 during the long-term testing. Ash ammonia levels ranged from 47 to 391 ppm, on a weight basis, during the course of the long-term testing, as seen in Figure 5-15. However, the majority of the values were between 100 and 200 ppm. The measurements showed no correlation with load.

Additional hopper ash samples were taken from hoppers 1-4 and 2-4 during the detailed ammonia tests. Analyses of these samples showed that the ammonia concentration in the ash from hopper 1-4 was 92 ppm, while the ash from hopper 2-4 had an ammonia concentration of 6 ppm, indicating that most of the ammonia was found in the ash collected in the first row of ESP hoppers.

5.4.4 Air Preheater Pressure Differential

The pressure differentials across the air preheater (APH) were monitored during the long-term testing using plant instrumentation. A strip chart recorded the load and pressure differential data continuously, while printing out instantaneous readings at four-hour intervals. The instantaneous readings were logged and subsequently analyzed. The APH pressure drops at all loads were also normalized to full load to provide a better picture of what was happening in the air preheater.

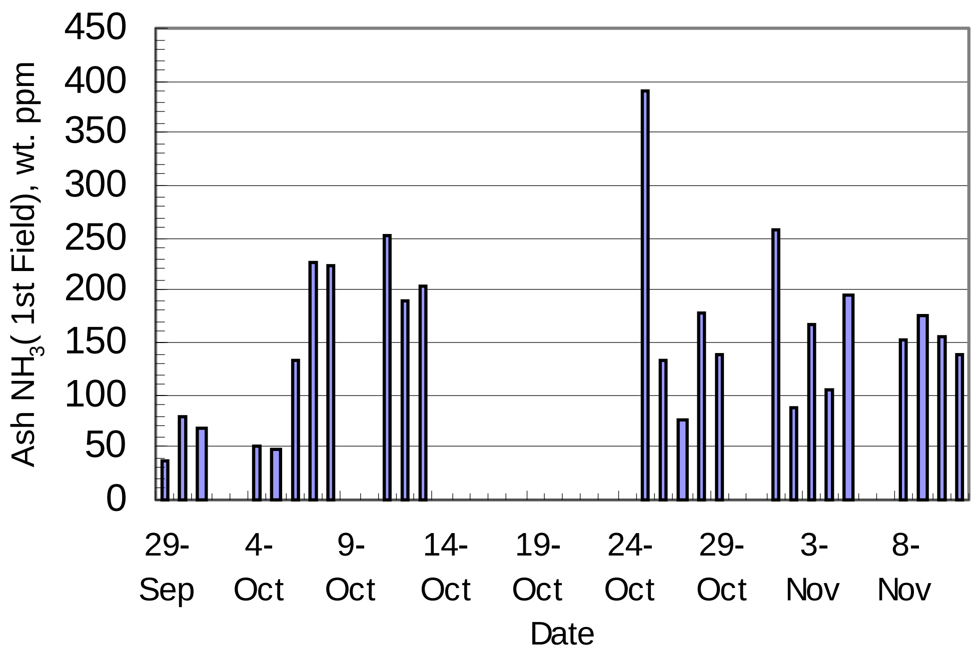


Figure 5-15
Ash NH_3 Concentrations

To normalize the differential pressures, it was expected that the relationship between load and pressure differential would be somewhat greater than first order but not second order. Load and APH pressure differential data from the first week were plotted and then curve fit using a power function. APH pressure differential was proportional to load to the 1.23 power. The APH pressure differential data were then normalized to 600 MW, using the 1.23 power correlation. The normalized APH pressure differential was then plotted versus time, as shown in Figure 5-16. The normalized APH differential pressure increased with time during the long-term testing.

To support this analysis, the raw data were sorted by load, and APH pressure differential was then plotted versus time for each air preheater. Figure 5-17 shows the APH pressure differential measured at three loads plotted versus time. The data show that the APH pressure differential increased at all three loads. At full load, the APH pressure differential increased about 1.3 inches H_2O (2.4 mm Hg), from 4.4 to 5.7 inches H_2O (8.2 to 10.6 mm Hg). Increases in APH pressure differential were also recorded at reduced loads.

The pressure differentials continued to be monitored following the completion of the long-term testing. Figure 5-18 shows three weeks of data logged after the end of the long-term testing. The air preheater pressure differentials began decreasing immediately after the long-term testing was completed. After about three weeks of operation with the urea turned off, the pressure differentials were essentially back to the levels recorded at the start of the long-term testing. Thus, it appears that the air preheater was able to clean itself in this time.

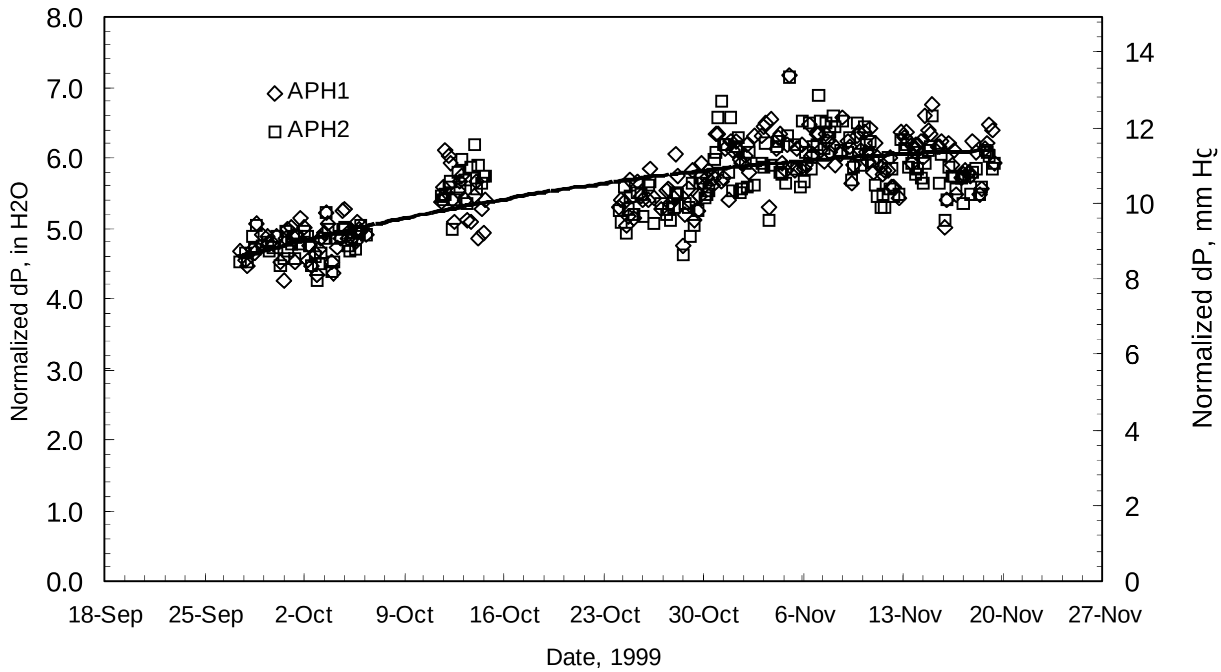


Figure 5-16
APH Pressure-Drop History, Normalized to 600 MW

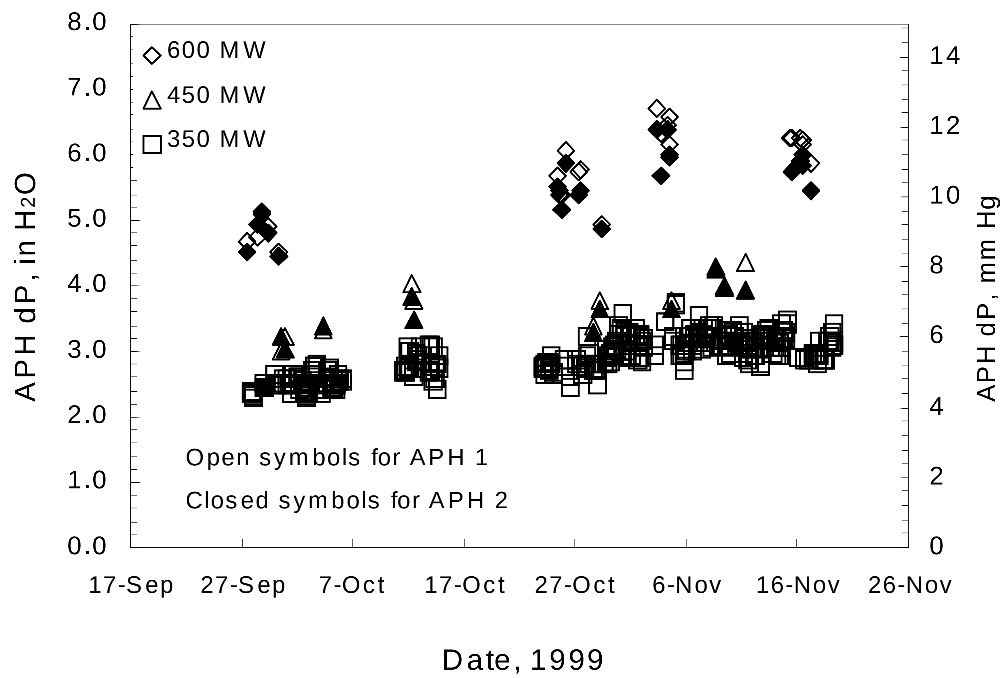
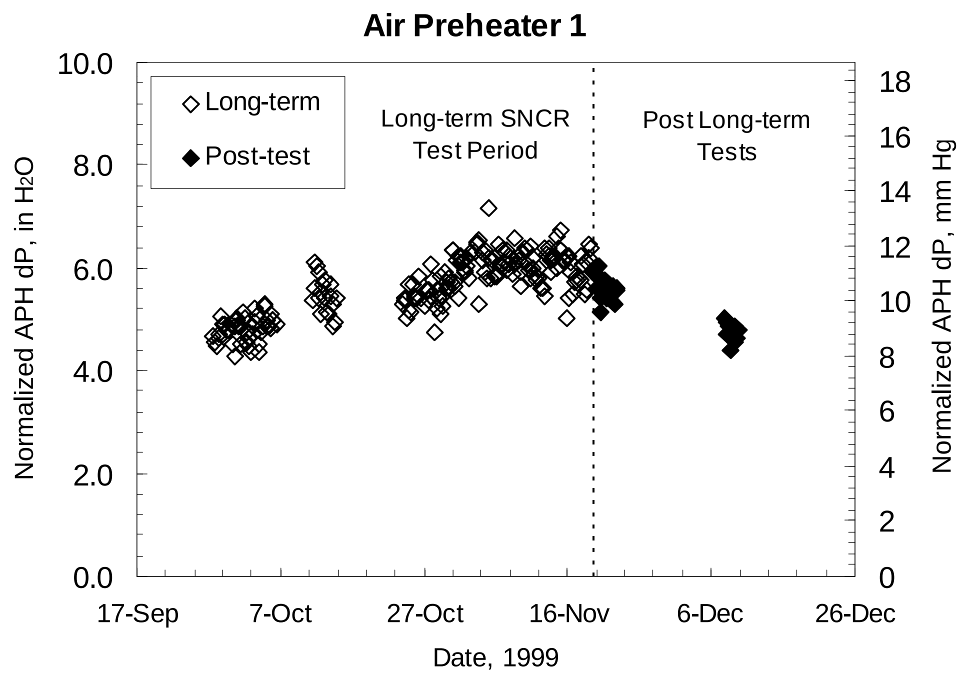
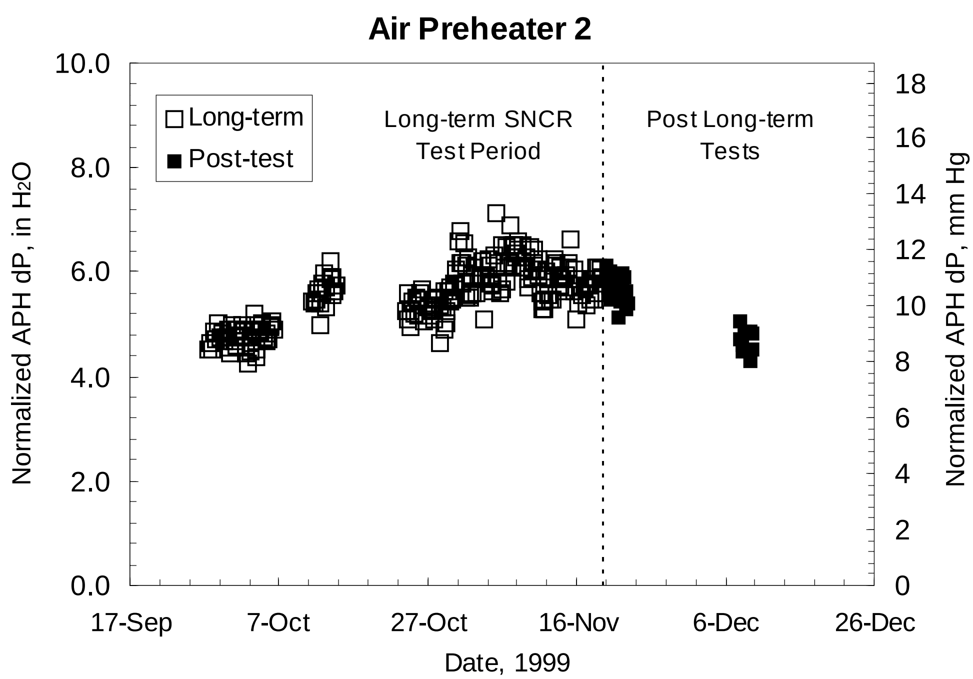


Figure 5-17
APH Pressure-Drop History



(a) Air Preheater No. 1



(b) Air Preheater No. 2

Figure 5-18
APH Normalized Pressure-Drop History, including Post Long-term Tests

5.4.5 Furnace Exit Temperature

The Spectratemp® optical temperature instruments were used to monitor furnace exit temperature throughout the program. Figures 5-19 and 5-20 show the temperatures plotted versus load for both the optimization tests and long-term demonstration testing for the North and South sides of the furnace, respectively. Furnace temperatures varied from about 2500°F to 2600°F (1370°C to 1427°C) at full load during the optimization tests. These temperatures decreased to between 2000°F and 2100°F (1093°C to 1149°C) at minimum load. The long-term data show that full-load temperatures in the North side of the furnace were about 100°F (56°C) lower than those measured during the optimization tests. In comparison, full-load temperatures in the South side of the furnace were essentially equal for both test campaigns. At low load, temperatures measured during the long-term demonstration were slightly higher than those measured during the optimization tests on both sides of the furnace.

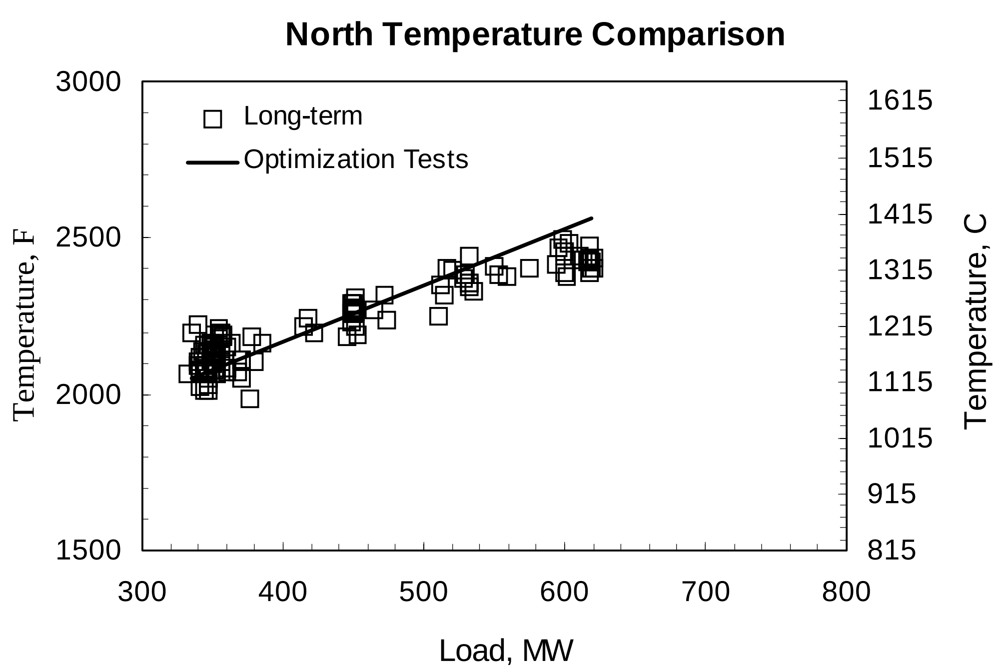


Figure 5-19
Furnace Exit Spectratemp® Temperature Trends: North Side

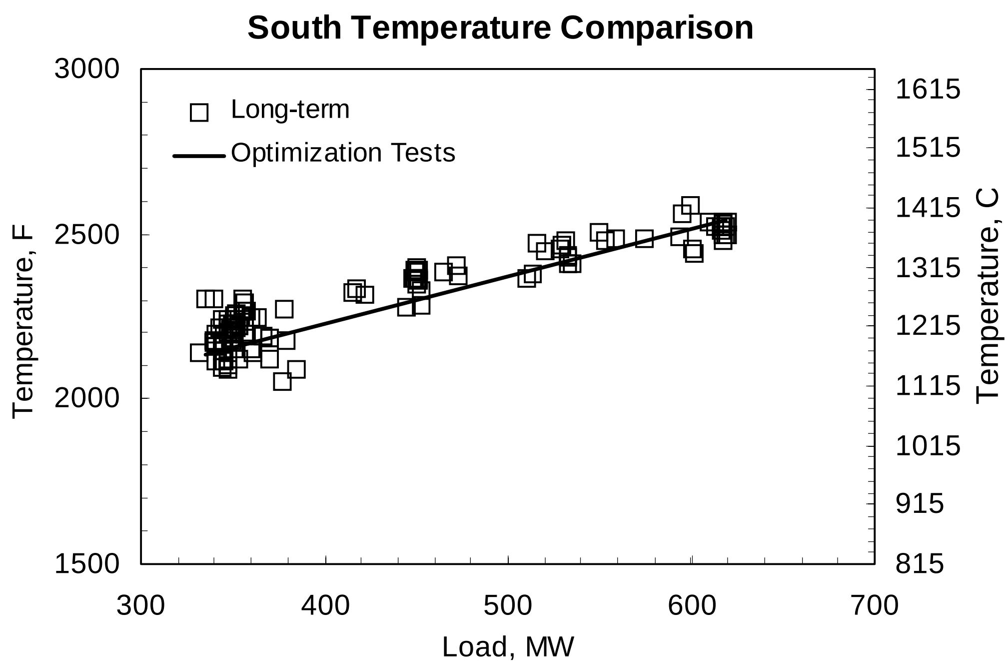


Figure 5-20
Furnace Exit Spectratemp® Temperature Trends: South Side

5.4.6 Opacity

One potential balance-of-plant impact of SNCR is that submicron ammonium salt particles formed as a result of ammonia slip could be emitted from the stack, resulting in increased opacity. However, an AEP review of the opacity readings from the optimization and long-term test periods at Cardinal revealed no correlation between higher opacity and SNCR operation. There were no substantiated reports of stack fallout during the optimization or long-term test periods. The lack of an impact on opacity is consistent with the NH_3 measurements made throughout the system (see Section 5.4.2) that showed that over 90% of the NH_3 present at the economizer exit was removed prior to reaching the stack. This result is also consistent with optical particle size measurements performed at the EPRI/PG&E ASCR pilot plant.[(3)] These optical measurements showed that there was no submicron particle formation as a result of homogeneous nucleation resulting from the NH_3/SO_3 reactions. Rather, heterogeneous nucleation on ash particles appeared to be the preferred condensation mechanism.

5.4.7 Water Impacts

Ammonia slip or ammonium salts adsorbed onto the surface of the fly ash in the flue gas could increase ammonia levels in the plant's fly ash pond discharge. AEP performed sampling and analyses at four locations along the fly ash waste stream during the SNCR demonstration. The results of the analyses showed a direct correlation between higher ammonia concentrations and SNCR operation. However, the ammonia concentrations in Outfall 019 discharge, the permitted outfall, were well below the most stringent regulatory limitations.

6
PERFORMANCE OF THE CONTINUOUS AMMONIA ANALYZERS

Two *in situ* continuous ammonia analyzers, one manufactured by Norsk Elektro Optikk (NEO) and the other by AltOptronic, were installed at the economizer exit for the long-term demonstration. As described in Section 3, both instruments utilize tunable infrared diode lasers to perform absorption spectroscopy across the duct. The NEO instrument was located in the North duct, and the AltOptronic instrument in the South duct. The analyzer outputs were recorded on a Campbell Scientific data logger.

Because of the structure of the long-term demonstration, there were no systematic tests performed to vary the NH_3 slip levels and compare the instrument outputs with wet chemical NH_3 measurements. When wet chemical measurements were taken at the various loads during the long-term tests, an effort was made to obtain not only a composite duct average (either the North or South duct) but also a composite sample from the ports adjacent to the continuous analyzers.

The NEO analyzer was on line continuously from the week of October 25, 1999 through the end of the long-term demonstration on November 19, 1999. Figures 6-1 through 6-4 show the continuous NH_3 measurements from the NEO analyzer. Each open symbol represents a five-minute average. The solid symbols are the wet chemical NH_3 measurements. Comparing the continuous NEO output to the wet chemical results shows, in general, good agreement. It should be noted that the continuous NH_3 instruments measure NH_3 on a wet basis, while the wet chemical measurement is on a dry basis. For the coal fired in Cardinal Unit 1, the wet-to-dry correction was nominally 10%. The data shown in Figures 6-1 through 6-4 are on an as-measured basis; for a direct comparison, the wet chemical values should be reduced by about 10%.

The AltOptronic instrument was installed for about the same length of time, but because of hardware and alignment problems, the instrument only provided continuous data for a period of nominally two to three days, November 11-12 and November 15, 1999. These results are shown in Figures 6-5 and 6-6, along with the wet chemical measurements. As with the NEO, the AltOptronic measurements appear to be in reasonably good agreement with the wet chemical measurements. Being on line for only a couple of days should not reflect on the overall capability of the AltOptronic instrument. For the current long-term test program, there were neither the manpower resources nor time to address some of the initial startup issues encountered with the instrument. The AltOptronic and NEO instruments have been successfully on line for several months as part of another EPRI project in Florida, which is demonstrating various continuous ammonia analyzers. [4]

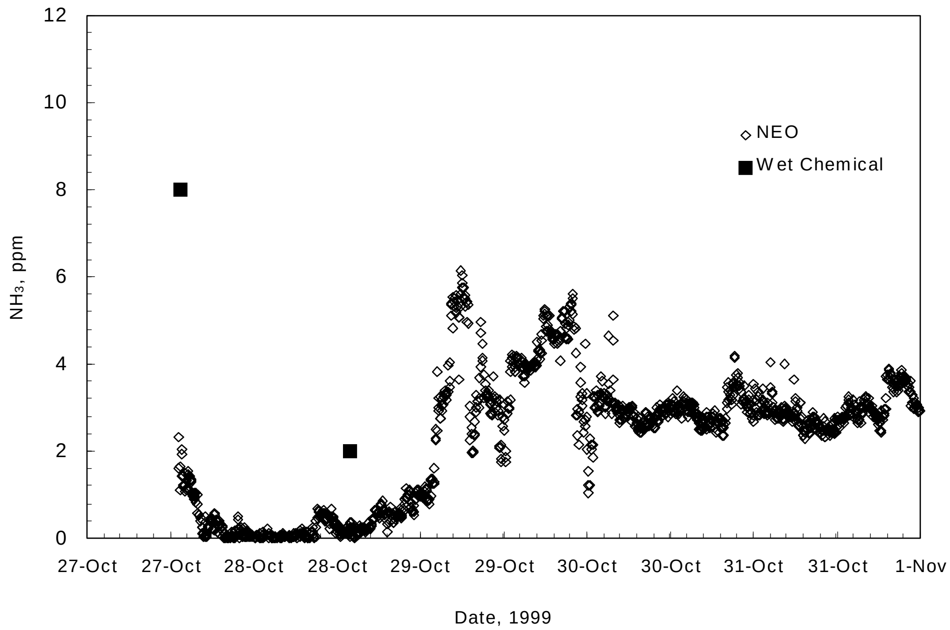


Figure 6-1
NEO Continuous NH_3 Analyzer, Week of October 25

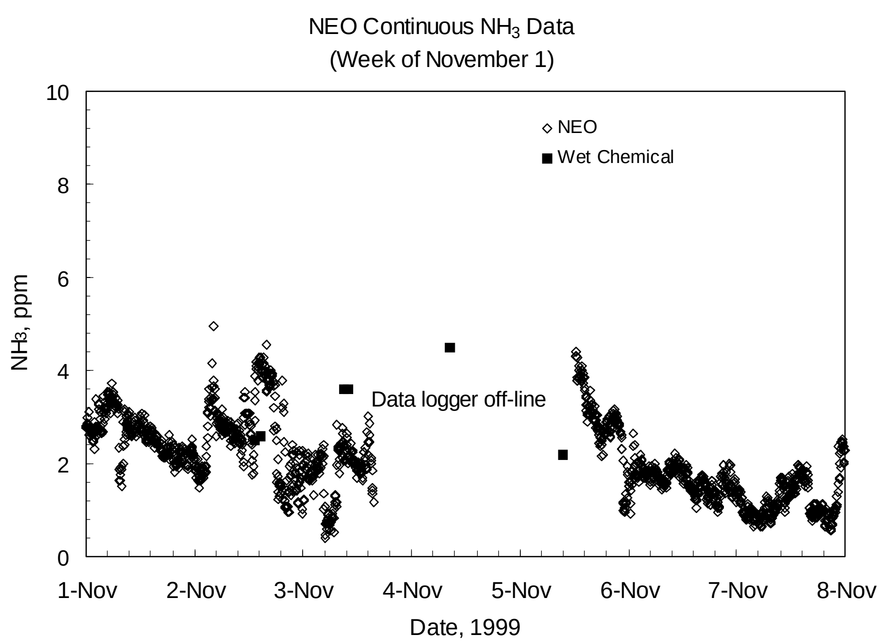


Figure 6-2
NEO Continuous NH_3 Analyzer, Week of November 1

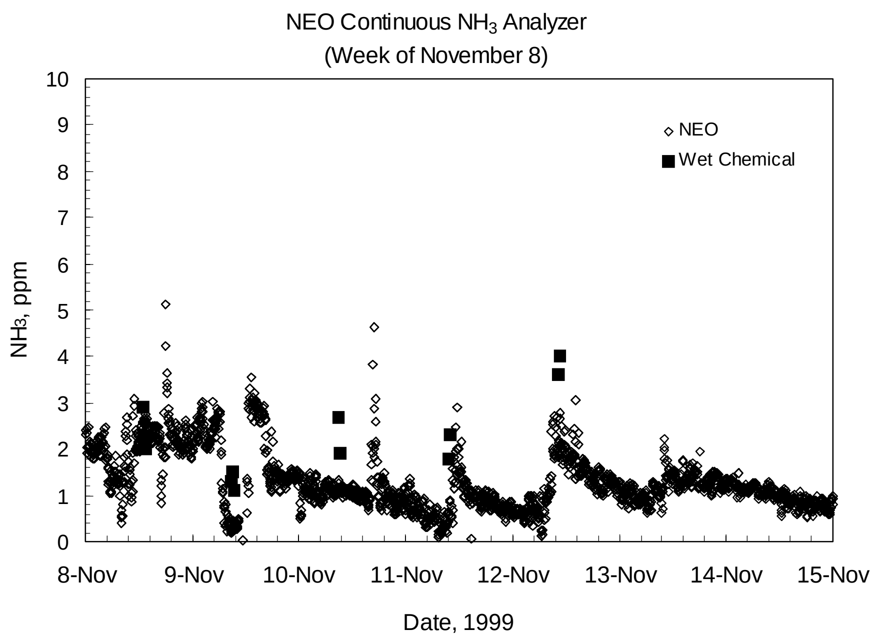


Figure 6-3
NEO Continuous NH_3 Analyzer, Week of November 8

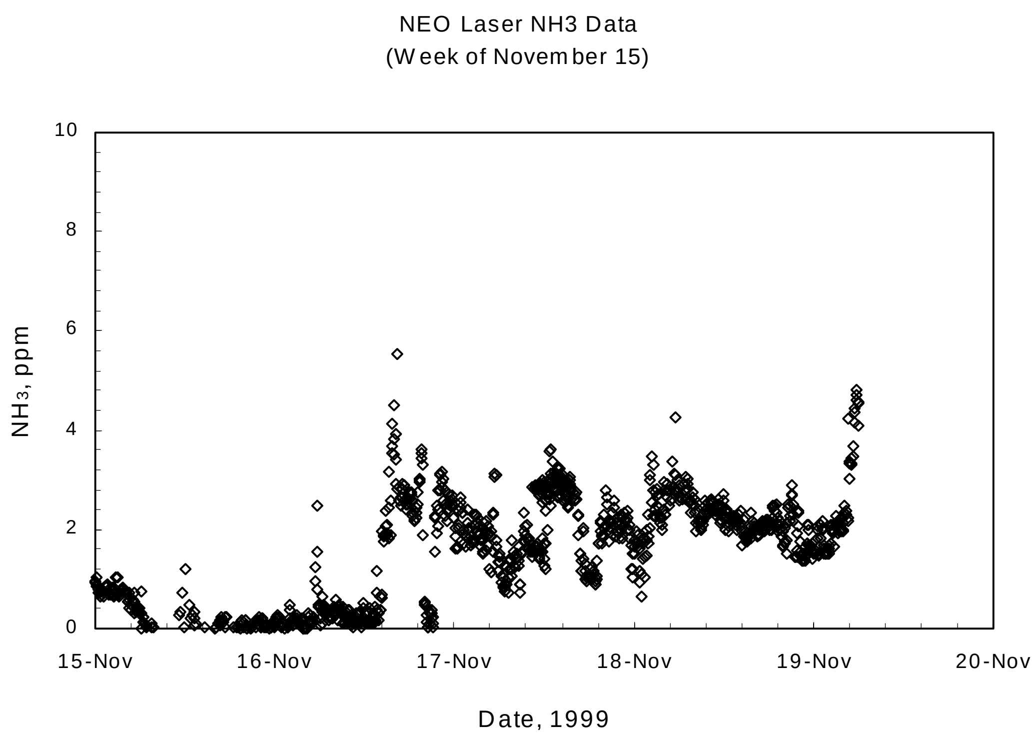


Figure 6-4
NEO Continuous NH_3 Analyzer, Week of November 14

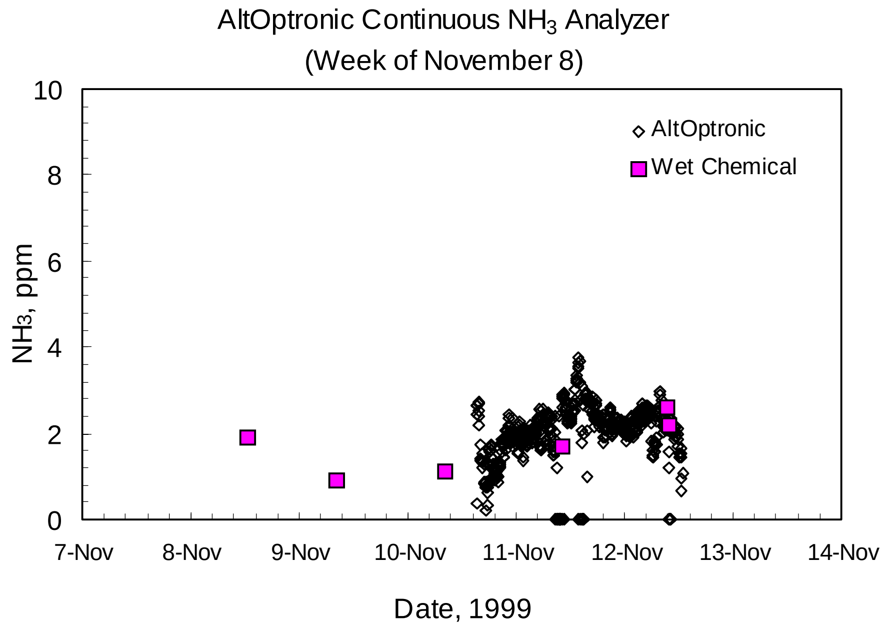


Figure 6-5
AltOptronic Continuous NH_3 Analyzer, Week of November 8

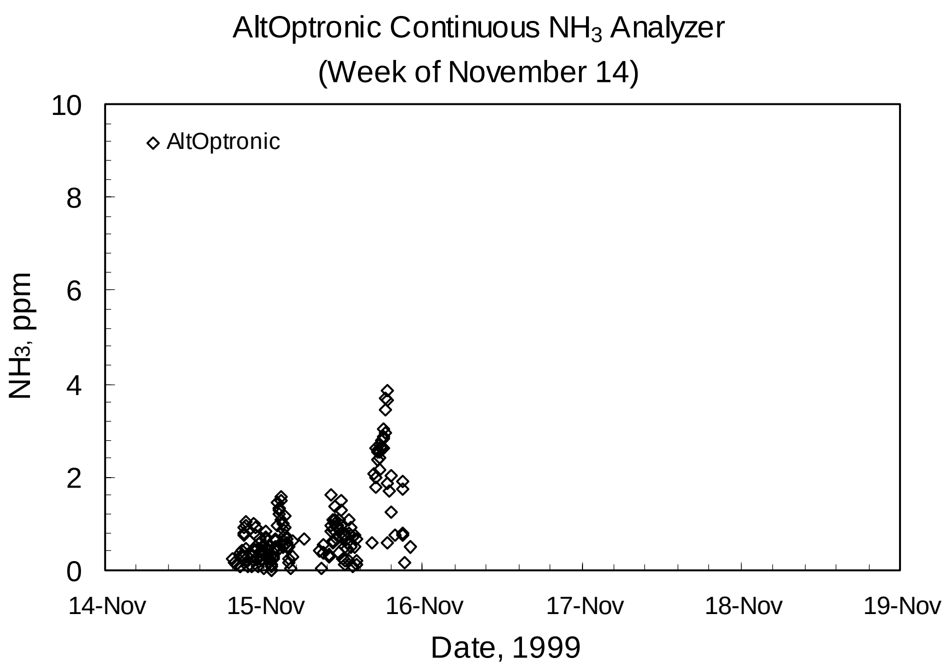


Figure 6-6
AltOptronic Continuous NH_3 Analyzer, Week of November 14

Figure 6-7 shows plots of the NH_3 readings from the NEO analyzer, along with the average temperature from the Spectratemp units and the loads for the period October 27 through 31, 1999. Looking at how these parameters vary with time, the output from the NEO analyzer appears to be following the process:

- Just before 12:00 on October 27, the temperature drops and a slight increase in NH_3 slip is noted.
- After the load increase and decrease from nominally 12:00 to 17:00 on October 27, the temperature decreases and the NH_3 increases.
- During the load changes on October 28, the temperatures respond to the load change, as does the NH_3 slip. For the load ramp to 600 MW, the slip first increases, probably the result of installing the MNLs. The NH_3 then decreases with load, and finally begins to increase as the temperature continues to decrease while the load remains at nominally 350 MW between 13:00 – 23:00 on October 28.
- For the two-day period October 29 through 30, the load was steady at 350 MW. There were two instances during this time interval when the temperature decreased (22:00 on October 29 and 19:00 on October 30), and the NH_3 is seen to increase.

Thus, it appears that the NEO analyzer is able to follow the process. With further experience and verification, this instrument may prove to be a valuable process control input for SNCR systems.

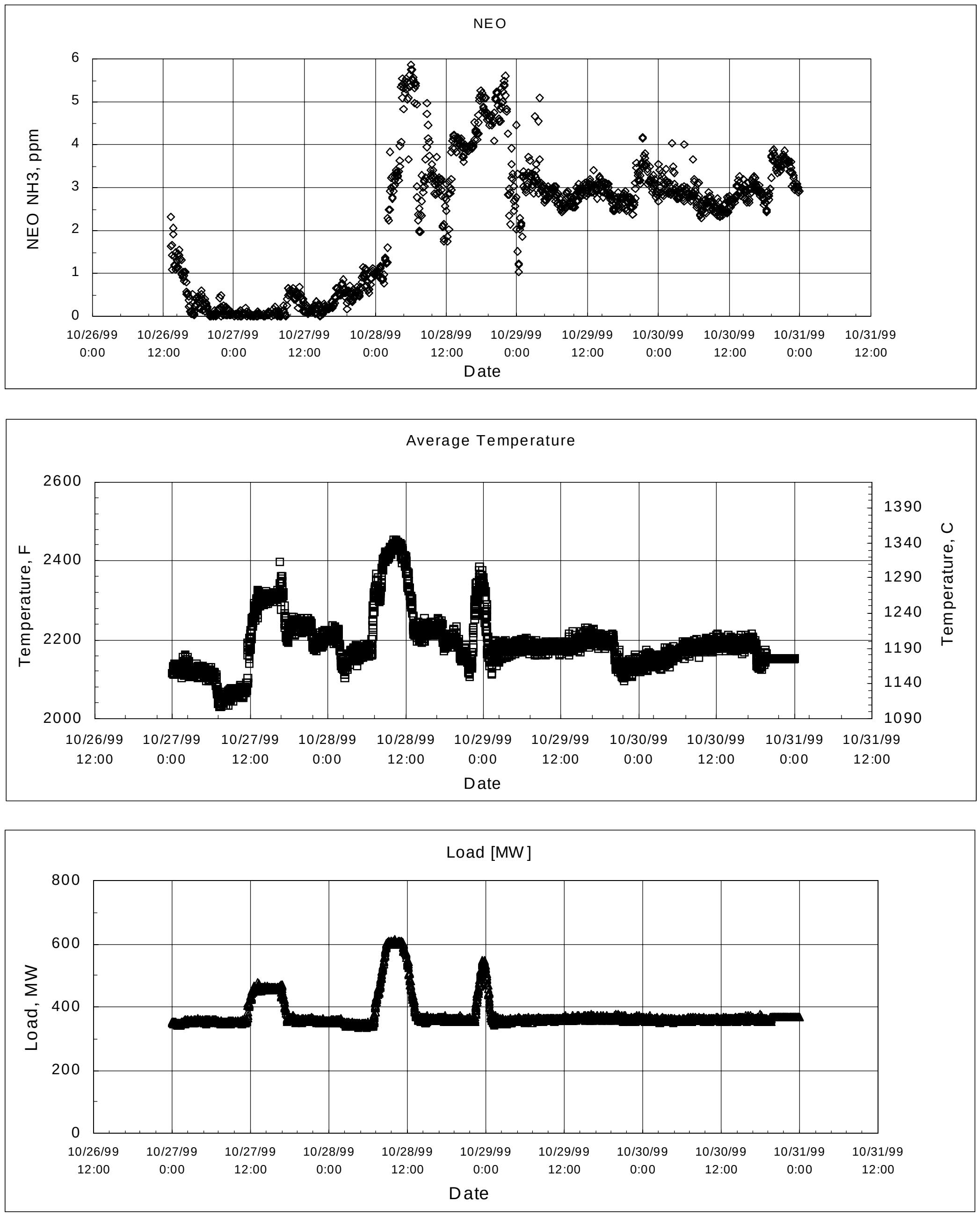


Figure 6-7
Continuous NH_3, Temperature and Load Trends with Time, Cardinal Unit 1

7
SNCR ECONOMICS

SNCR costs are highly site-specific and depend on a number of factors, including:

- Boiler size and type
- Required SNCR performance over the load range
- Location of the SNCR temperature window
- Injection system
- Control system complexity
- SNCR chemical

The costs of the Cardinal Unit 1 SNCR system are broken down into the following components:

- Capital costs
- Installation costs
- Chemical costs
- Efficiency penalties

Each of these cost components is reviewed below.

Capital and Installation Costs

The installed cost for the SNCR system was $6.5 million, including $3.5 million in capital costs and $3.0 million for installation. This amount is equivalent to $10.8/kW. Of these costs, $600,000, or $1.0/kW, were attributed to costs associated with retrofitting a pressurized unit. Thus, dealing with a pressurized boiler accounted for about 10% of the capital costs.

Chemical Costs

The chemical costs were $377/hour at full load for the long-term testing, based on a reagent cost of $0.72 per gallon ($0.19/liter). Table 7-1 shows the SNCR system chemical costs at full, mid, and low loads, along with the hourly cost.

During the long-term test period, the SNCR system was operated for 960 hours and consumed about 241,000 gallons of NO_xOUT A (a nominal 50% urea solution), for a total cost of $174K. At a nominal cost of $0.72/gallon ($0.19/liter), the average chemical costs were $180/hr.

However, as discussed in Section 5, the unit operated at low load for about 70% of the time during the long-term demonstration.

Table 7-1
Chemical Usage and Cost (based on urea cost of $0.72/gallon)

Load, MW	Urea Flow, gpm (lpm)	Approx. Cost, $/hr
600	7.8 (29.5)	337
450	4.4 (16.7)	188
350	2.8 (10.6)	122

Efficiency Penalties

The primary boiler efficiency penalty for the Cardinal Unit 1 SNCR system is the energy loss associated with evaporating the urea solution injected into the upper furnace. When the solution is injected into the flue gas, some energy that would ordinarily be transferred to the steam is used to evaporate the solution. This loss is partially offset by the energy released as the urea reacts. Figure 7-1, taken from the SNCR Feasibility and Economic Evaluation Guidelines for Fossil-Fired Utility Boilers (EPRI TR-103885), shows how the efficiency penalty varies with the amount of solution injected (shown as gpm/MW or lpm/MW) and the concentration of urea in solution. The evaporation penalty is completely offset if the injected solution has a urea concentration of nominally 23%.

Table 7-2 shows the boiler efficiency penalty associated with vaporization for the three loads during the long-term demonstration. These calculations assumed a plant net heat rate of 10,000 Btu/kW-hr.

Table 7-2
Efficiency Penalty

Load, MW	**Urea Concentration** Wt%	**Solution Flowrate** gpm (lpm)	**Efficiency Penalty** %
600	8	42 (159)	0.5
450	8	38 (144)	0.3
350	10	30 (114)	0.2

In addition to the vaporization losses, there are some minor losses associated with operating the solution pumps and lance cooling water pumps, and providing compressed air to the atomizers.

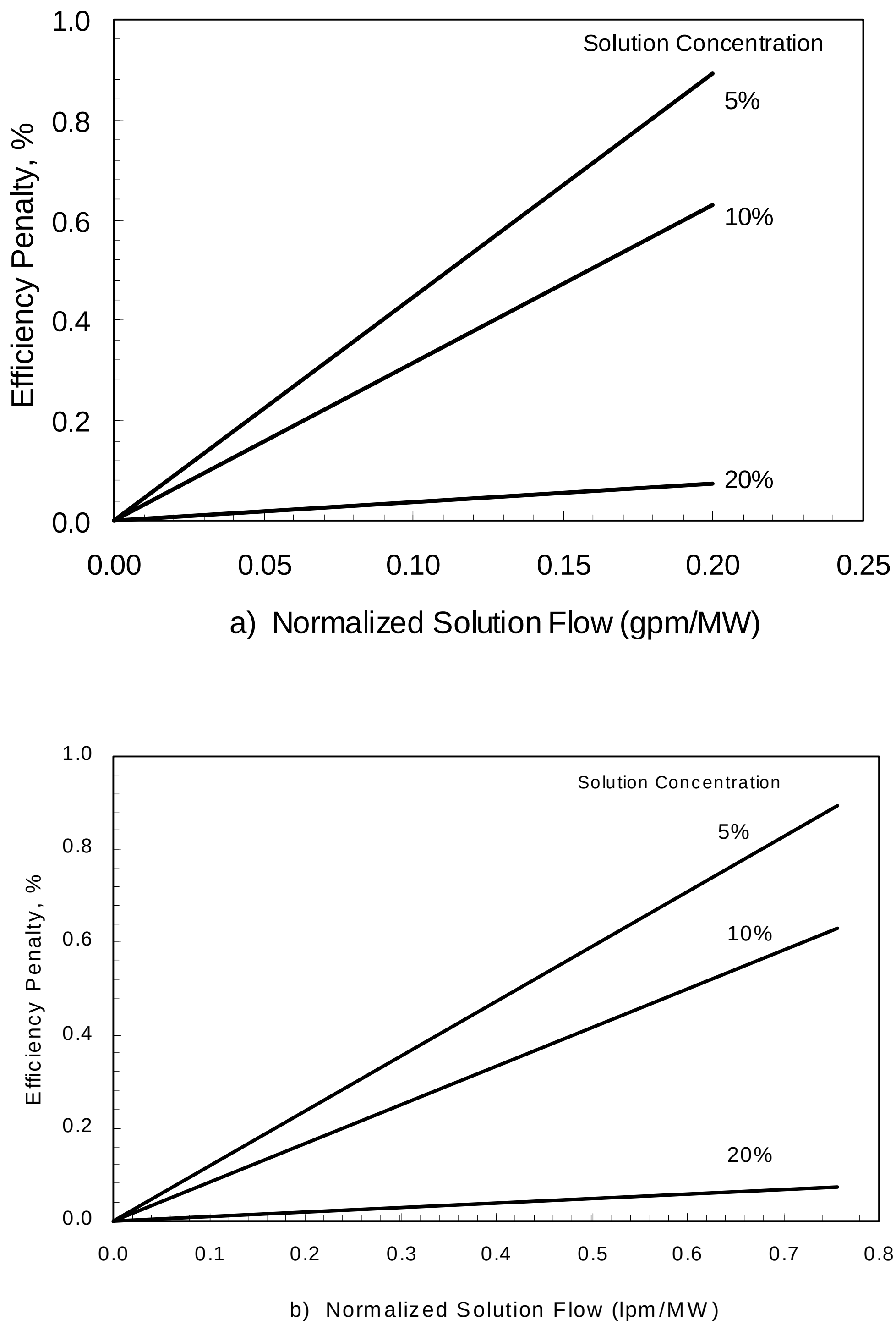


Figure 7-1
Effect of Aqueous Urea Solution Injection on Boiler Efficiency

8
CONCLUSIONS

The following conclusions can be drawn based on the results of this test program:

- During the long-term demonstration, the SNCR system achieved its stated performance goals of 30-percent NO_x reduction with less than 5-ppm NH_3 slip at loads of 450 MW and lower. SNCR performance at the three primary test loads were as follows:

Load, MW	NO_x Reduction, %	NH_3 Slip, ppm
600	25	4
450	29	2
350	30	3

  At full load the system achieved the target NO_x level programmed into the PLC. However, because the baseline NO_x levels were lower than expected, the system only required a 25% NOx reduction to reach the target.

- The SNCR system operated as desired for the duration of the long-term demonstration with no operating problems which precluded the system from achieving the target performance.
- The 960 hours of long-term demonstration resulted in an increase in air preheater pressure differential of about 1.3 inches H_2O (2.4 mm Hg) from 4.4 to 5.7 inches H_2O (8.2 to 10.6 mm Hg). A longer test period would be needed to determine whether this increasing trend continues or levels off.
- Air preheater pressure differential was monitored after completion of the long-term SNCR demonstration. The pressure differential was found to have decreased back to the pretest levels after about three weeks of operation, apparently as a result of self-cleaning, since the air preheater was not washed.
- Ash samples taken from hoppers in the first ESP field showed NH_3 concentrations between nominally 100 and 200 ppm. Ash NH_3 concentration was about 90% lower in samples taken from the second ESP field hoppers.
- As the gases pass through the unit from the economizer to the stack, over 90 percent of the ammonia initially present is removed in either the APH or ESP before exiting the stack.
- Two *in situ* continuous NH_3 monitors, based on infrared laser technology, were evaluated during the long-term demonstration. While no systematic tests of these monitors were

performed, the analyzers appeared to show reasonable agreement with wet chemical measurements.

- N_2O emissions measured during the optimization testing varied from 6 to 17 percent of the NO_x reduced over the load range, depending on load.
- The installed cost of the Cardinal Unit 1 SNCR system was about $6,500,000, or $10.8/kW. About ten percent of this amount was attributed to modifications required for a pressurized furnace. The operating costs included both chemical costs and efficiency penalties. At full load, chemical usage was about 7.8 gallons/minute (29.5 liters/min), equivalent to $337/hour, based on a chemical cost of $0.72/gallon ($0.19/liter). The calculated efficiency penalty was about 0.5% at full load.

9
REFERENCES

1. Muzio, L.J., Quartucy, G.C., *State of the Art Assessment: SNCR Technology*, (TR-102414), September 1993.

2. Muzio, et. al., *N_2O Formation in Selective Non-Catalytic NO_x Reduction Processes*, published in the Proceedings: 1991 Joint Symposium on Stationary Combustion Control, GS-7447, November 1991.

3. Teixeira, D. P. et. al., "Results of Catalyst Tests at the PG&E/EPRI ASCR Pilot Plant", EPRI/EPA Joint Symposium on Stationary Combustion NOx Control, Book 3, May 16-19, 1995.

4. Shiomoto, G.H., Muzio, L.J., Broske, D., Engelmeyer, A., *Update of the EPRI Continuous Ammonia Analyzer Demonstration Project*, 2nd EPRI SCR Workshop, Memphis, TN, April 2000.

A
OPTIMIZATION DATA - SORTED CHRONOLOGICALLY

Optimization Data - Sorted Chronologically

Date	Test	Load	Mills	APH del P				SNCR INJECTION SYSTEM OPERATING DATA							GASEOUS EMISSIONS DATA							CALCULATED DATA				CEM Data			Economizer Profile Available		COMMENTS
				APH 1		APH 2		Urea Flow		Water Flow		Sol'n Flow		Injection Levels	O_2	NO_x	NO_x	N_2O	CO	NH_3	NH_3 sample	Overall	del NO	del N_2O/	del CO	NOx	NOx	dNOx			
1999	No.	MW	In Serv	in H_2O	mm Hg	in H_2O	mm Hg	gph	lpm	gpm	lpm	gph	lpm	in Service	%	ppmc	lb/MMBtu	ppm	ppm	ppm	type	NSR	%	del NO, %	ppm	#/M	ppmc	[%]	NO_x	NH_3	
15-Mar	1	595	1-5	nr	nr	nr	nr	0	0	0	0	0	0	na	4.55	503	0.686	0	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	Baseline
15-Mar	2	595	1-5	nr	nr	nr	nr	480	30	nr	nr	na	na	1	4.53	497	0.677	0	20	0.0	na	0.86	1.1	0.0	0	nr	nr	nr	Y	N	Lvl 1 Check
15-Mar	3	595	1-5	nr	nr	nr	nr	510	32	nr	nr	na	na	1,2	4.50	436	0.595	0	20	0.0	na	0.91	13.0	0.0	0	nr	nr	nr	Y	N	Lvls 1,2
15-Mar	3b	596	1-5	nr	nr	nr	nr	0	0	0	0	0	0	na	4.63	500	0.682	0	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	N	N	BL Repeat
16-Mar	4	616	1-5	5.0	9.3	4.2	7.8	0	0	0	0	0	0	na	4.85	513	0.699	17	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	Baseline
16-Mar	5	616	1-5	5.0	9.3	4.2	7.8	510	32	30	114	2321	146	2,3	4.55	463	0.630	25	22	0.0	na	0.88	7.9	19.3	2	nr	nr	nr	Y	N	Levels 2,3
16-Mar	6	616	1-5	5.0	9.3	4.2	7.8	510	32	30	114	2321	146	2,3	4.60	414	0.565	29	25	0.0	na	0.88	17.8	14.7	5	nr	nr	nr	Y	N	Decr Zone 3 Liquid
16-Mar	7	616	1-5	5.0	9.3	4.2	7.8	0	0	0	0	0	0	na	4.53	497	0.677	22	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	BL Repeat
16-Mar	8	615	1-5	4.8	9.0	3.7	6.9	510	32	34	129	2549	161	2,3	4.38	440	0.599	40	23	1.8	P	0.90	10.5	38.1	3	nr	nr	nr	Y	P	Incr Zone 2 Liquid
16-Mar	9	615	1-5	4.8	9.0	3.7	6.9	0	0	0	0	0	0	na	4.68	529	0.721	31	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	BL Repeat
17-Mar	10	610	1-5	4.9	9.2	4.8	9.0	0	0	0	0	0	0	na	4.58	485	0.661	18	18	0.1	S	0.00	0.0	na	0	nr	nr	nr	Y	S	Baseline
17-Mar	11	610	1-5	4.9	9.2	4.8	9.0	241	15	13	48	1005	63	3	4.43	443	0.603	22	20	0.0	na	0.44	7.7	0.0	2	nr	nr	nr	Y	N	Level 3 Design
17-Mar	12	610	1-5	4.9	9.2	4.8	9.0	241	15	16	61	1202	76	3	4.35	435	0.593	23	20	0.0	na	0.44	8.8	14.2	2	nr	nr	nr	Y	N	Vary Liquid
17-Mar	13	607	1-5	4.8	9.0	4.7	8.8	240	15	10	36	812	51	3	4.20	402	0.547	30	20	0.0	na	0.45	14.8	18.5	2	nr	nr	nr	Y	N	Vary Liquid
17-Mar	14	607	1-5	4.8	9.0	4.7	8.8	0	0	0	0	0	0	na	4.23	440	0.600	24	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	BL Repeat
17-Mar	15	607	1-5	4.8	9.0	4.7	8.8	240	15	16	60	1189	75	3	4.05	396	0.539	31	22	1.1	D	0.49	8.8	19.8	2	nr	nr	nr	Y	N	Vary Liquid
17-Mar	16	608	1-5	4.9	9.2	4.8	9.0	240	15	16	61	1202	76	3	4.65	421	0.574	29	22	0.0	na	0.46	7.5	17.9	2	nr	nr	nr	Y	N	Decr Top MNL Air P
17-Mar	17	608	1-5	4.9	9.2	4.8	9.0	240	15	16	60	1192	75	3	4.80	425	0.579	29	22	0.0	na	0.46	7.7	18.6	2	nr	nr	nr	Y	N	Decr Top MNL Air P
17-Mar	18	608	1-5	4.9	9.2	4.8	9.0	240	15	16	60	1192	75	3	4.75	427	0.581	30	22	0.0	na	0.46	7.0	23.5	2	nr	nr	nr	Y	N	Decr Top MNL Air P
17-Mar	19	608	1-5	4.9	9.2	4.8	9.0	240	15	16	60	1192	75	3	4.75	424	0.577	28	22	0.0	na	0.46	7.6	0.0	2	nr	nr	nr	Y	N	Decrease Air P
17-Mar	20	608	1-5	4.9	9.2	4.8	9.0	240	15	9	33	764	48	3	4.55	421	0.574	27	22	0.0	na	0.47	6.7	14.3	2	nr	nr	nr	Y	N	A,D MNL OOS
17-Mar	21	608	1-5	4.9	9.2	4.8	9.0	420	26	9	33	944	60	3	4.73	420	0.573	30	22	0.0	na	0.81	8.2	20.8	2	nr	nr	nr	Y	N	Increase NSR
17-Mar	22	608	1-5	4.9	9.2	4.8	9.0	0	0	0	0	0	0	na	4.70	481	0.655	24	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	BL Repeat
18-Mar	23	611	1-5	5.2	9.7	5.0	9.3	0	0	0	0	0	0	na	4.70	472	0.643	22	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	Baseline
18-Mar	24	611	1-5	5.2	9.7	5.0	9.3	420	26	9	34	965	61	3	4.43	402	0.547	28	25	1.6	P	0.79	13.1	10.8	5	nr	nr	nr	Y	P	Test 20 Repeat
18-Mar	25	611	1-5	5.2	9.7	5.0	9.3	417	26	13	49	1195	75	3	3.30	366	0.499	27	42.5	2.4	P	0.86	13.3	5.9	23	nr	nr	nr	Y	P	All MNLs in service
18-Mar	26	611	1-5	5.2	9.7	5.0	9.3	0	0	0	0	0	0	na	3.85	444	0.604	20	23.5	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	BL Repeat
18-Mar	27	611	1-5	5.2	9.7	5.0	9.3	420	26	13	49	1199	76	3	4.15	390	0.531	35	22	0.0	na	0.81	14.1	27.1	-2	nr	nr	nr	Y	N	Decrease Air P

Date 1999	Test No.	Load MW	Mills In Serv	APH del P: APH 1 in H_2O	APH del P: APH 1 mm Hg	APH del P: APH 2 in H_2O	APH del P: APH 2 mm Hg	SNCR Injection System Operating Data: Urea Flow gph	Urea Flow lpm	Water Flow gpm	Water Flow lpm	Sol'n Flow gph	Sol'n Flow lpm	Injection Levels in Service	Gaseous Emissions Data: O_2 %	NO_x ppmc	NO_x lb/MMBtu	N_2O ppm	CO ppm	NH_3 ppm	NH_3 sample type	Calculated Data: Overall NSR	del NO %	del N_2O/ del NO, %	del CO ppm	CEM Data: NOx #/M	NOx ppmc	dNOx [%]	Economizer Profile Available: NO_x	NH_3	COMMENTS
18-Mar	28	611	1-5	5.2	9.7	5.0	9.3	168	11	5	20	484	31	3	4.25	441	0.600	29	21	0.0	na	0.32	3.7	60.6	-3	nr	nr	nr	Y	N	Top MNLs only
18-Mar	29	605	1-5	4.8	9.0	4.7	8.8	336	21	2	9	479	30	3	4.38	441	0.601	31	22	0.0	na	0.64	4.5	60.1	-2	nr	nr	nr	Y	N	Increase NSR
19-Mar	30	608	1-5	4.8	9.0	4.7	8.8	0	0	0	0	0	0	na	4.53	473	0.644	22	18	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	Baseline
19-Mar	31	610	1-5	4.8	9.0	4.7	8.8	168	11	5	20	480	30	3	4.50	426	0.580	27	22	0.0	na	0.29	15.2	7.6	4	nr	nr	nr	Y	N	Zone 3 Middle MNLs
19-Mar	32	610	1-5	4.8	9.0	4.7	8.8	336	21	2	9	481	30	3	4.45	419	0.571	32	22	0.0	na	0.59	16.2	12.8	4	nr	nr	nr	Y	N	Increase NSR
19-Mar	33	610	1-5	4.8	9.0	4.7	8.8	234	15	1	4	300	19	3	4.28	441	0.601	27	22	0.0	na	0.41	10.6	10.5	4	nr	nr	nr	Y	N	Zone 3 Bot MNLs
19-Mar	34	610	1-5	4.8	9.0	4.7	8.8	0	0	0	0	0	0	na	4.40	480	0.654	22	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	BL Repeat
19-Mar	35	562	2-5	4.2	7.8	4.1	7.7	0	0	0	0	0	0	na	4.48	458	0.623	23	18	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	Baseline - 550 MW
19-Mar	36	562	2-5	4.2	7.8	4.1	7.7	210	13	13	48	979	62	3	4.55	429	0.585	28	21	0.0	na	0.43	6.7	17.6	3	nr	nr	nr	Y	N	Zone 3
19-Mar	37	562	2-5	4.2	7.8	4.1	7.7	366	23	11	41	1008	64	3	4.60	412	0.561	32	22	3.5	na	0.75	10.9	19.0	4	nr	nr	nr	Y	N	Increase NSR
19-Mar	38	562	2-5	4.2	7.8	4.1	7.7	367	23	25	93	1838	116	2	4.70	392	0.534	32	22	0.0	na	0.75	15.8	13.7	4	nr	nr	nr	Y	N	Zone 2
19-Mar	39	562	2-5	4.2	7.8	4.1	7.7	367	23	40	150	2740	173	1,2	4.70	378	0.515	29	22	0.0	na	0.75	18.8	7.8	4	nr	nr	nr	Y	N	Zone 2 + Z1 rear wall
19-Mar	40	562	2-5	4.2	7.8	4.1	7.7	410	26	40	151	2799	177	2,3	4.68	353	0.480	37	25	0.0	na	0.84	24.1	14.2	7	nr	nr	nr	Y	N	Zones 2,3
20-Mar	41	603	1-5	5.1	9.5	4.7	8.8	0	0	0	0	0	0	na	5.03	473	0.645	4	18	0.0	na	0.00	0.0	na	0	0.69	506	0.0	Y	N	Baseline
20-Mar	42	603	1-5	5.1	9.5	4.7	8.8	168	11	29	109	1902	120	2	4.83	420	0.572	10	22	0.0	na	0.32	9.9	24.7	4	0.61	447	11.6	Y	N	Zone 2
20-Mar	43	603	1-5	5.1	9.5	4.7	8.8	330	21	26	100	1908	120	2	4.85	382	0.520	14	22	0.0	na	0.63	18.3	18.3	4	0.57	418	17.4	Y	N	Increase NSR
20-Mar	44	603	1-5	4.8	9.0	4.7	8.8	480	30	23	87	1854	117	2	4.83	370	0.504	17	25	8.0	C	0.91	20.7	19.3	7	0.54	396	21.7	Y	C	Increase NSR
20-Mar	45	603	1-5	4.8	9.0	4.7	8.8	330	21	16	59	1260	79	2	4.70	403	0.549	15	23	0.0	na	0.63	12.7	28.3	5	0.59	433	14.5	Y	N	Increase NSR
20-Mar	46	603	1-5	4.8	9.0	4.7	8.8	330	21	16	60	1278	81	2	4.73	415	0.565	13	22	0.0	na	0.63	10.4	30.5	4	0.59	433	14.5	Y	N	Remove sidewall injs
20-Mar	47	603	1-5	4.8	9.0	4.7	8.8	226	14	18	66	1276	81	2	4.60	420	0.572	8	22	0.0	na	0.44	8.4	21.8	4	0.61	447	11.6	Y	N	Remove front corner injs
20-Mar	48	602	1-5	4.9	9.2	4.7	8.8	0	0	0	0	0	0	na	4.73	484	0.659	8	18	0.0	na	0.00	0.0	na	0	0.72	528	-4.3	Y	N	Baseline Repeat
20-Mar	49	602	1-5	4.9	9.2	4.7	8.8	244	15	16	61	1207	76	3	4.58	444	0.605	nr	21	0.0	na	0.45	7.3	0.0	3	0.61	447	12.9	Y	N	Zone 3
20-Mar	50	600	1-5	4.8	9.0	4.6	8.6	242	15	8	29	705	44	3	4.65	470	0.641	11	22	0.0	na	0.45	2.3	37.2	4	0.6	440	13.0	Y	N	Remove top pair
20-Mar	51	600	1-5	4.8	9.0	4.6	8.6	601	38	23	86	1972	124	2,3	4.45	348	0.474	20	25	10.1	C	1.13	26.6	10.7	7	0.5	367	27.5	Y	N	Zones 2,3
20-Mar	52	600	1-5	4.8	9.0	4.6	8.6	0	0	0	0	0	0	na	4.63	478	0.651	4	18	0.0	na	0.00	0.5	0.0	0	0.69	506	0.0	Y	N	Baseline Repeat
22-Mar	53	609	1-5	4.9	9.2	4.8	9.0	0	0	0	0	0	0	na	4.40	472	0.643	4	19	0.0	na	0.00	0.0	na	0	0.69	506	0.0	0	0	Baseline
22-Mar	54	609	1-5	4.9	9.2	4.8	9.0	243	15	8	30	725	46	2	4.45	451	0.615	7	22	0.0	na	0.45	4.7	14.8	3	0.64	469	7.2	0	0	Level 2
22-Mar	55	600	1-5	4.9	9.2	4.8	9.0	0	0	0	0	0	0	na	4.38	479	0.653	4	18	0.0	na	0.00	0.0	na	0	0.67	491	0.0	0	0	Baseline
22-Mar	56	600	1-5	4.9	9.2	4.8	9.0	299	19	17	63	1292	82	2	4.38	425	0.579	10	25	2.0	P	0.56	11.3	13.6	7	0.58	425	13.4	0	0	Level 2
22-Mar	57	600	1-5	4.9	9.2	4.8	9.0	152	10	19	72	1291	81	2	4.35	449	0.611	8	22	0.0	na	0.28	6.2	17.5	4	0.65	477	3.0	0	0	Decrease NSR

Optimization Data - Sorted Chronologically

Date	Test	Load	Mills	APH del P: APH 1		APH 2		SNCR INJECTION SYSTEM OPERATING DATA: Urea Flow		Water Flow		Sol'n Flow		Injection Levels	GASEOUS EMISSIONS DATA: O_2	NO_x	NO_x	N_2O	CO	NH_3	NH_3 sample	CALCULATED DATA: Overall	del NO	del N_2O/	del CO	CEM Data: NOx	NOx	dNOx	Economizer Profile Available		
1999	No.	MW	In Serv	in H_2O	mm Hg	in H_2O	mm Hg	gph	lpm	gpm	lpm	gph	lpm	in Service	%	ppmc	lb/MMBtu	ppm	ppm	ppm	type	NSR	%	del NO, %	ppm	#/M	ppmc	[%]	NO_x	NH_3	COMMENTS
22-Mar	58	600	1-5	4.9	9.2	4.8	9.0	468	30	13	51	1269	80	2	4.25	416	0.567	11	22	3.9	C	0.88	12.3	13.9	4	0.61	447	9.0	0	0	Increase NSR
22-Mar	59	597	1-5	4.9	9.2	4.7	8.8	299	19	20	75	1481	93	2	4.30	426	0.580	13	22	3.9	C	0.56	10.6	19.2	4	0.57	418	14.9	0	0	Decrease NSR, increase water
22-Mar	60	597	1-5	4.9	9.2	4.7	8.8	0	0	0	0	0	0	na	4.35	481	0.655	4	20	0.0	na	0.00	0.0	na	0	0.69	506	-3.0	0	0	Baseline
22-Mar	61	597	1-5	4.9	9.2	4.7	8.8	298	19	28	104	1948	123	2,3	4.35	384	0.523	16	22	0.0	na	0.55	20.2	12.8	2	0.54	396	21.7	0	0	Levels 2 & 3
22-Mar	62	597	1-5	4.9	9.2	4.7	8.8	450	28	25	94	1938	122	2,3	4.43	372	0.507	20	25	3.9	P	0.83	23.1	15.6	5	0.52	381	24.6	0	0	Increase NSR
22-Mar	63	597	1-5	4.9	9.2	4.7	8.8	0	0	0	0	0	0	na	4.50	488	0.665	5	18	0.0	na	0.00	0.0	na	0	0.69	506	0.0	0	0	Baseline repeat
23-Mar	64	607	1-5	4.8	9.0	4.7	8.8	0	0	0	0	0	0	na	4.60	478	0.651	3	18	0.0	na	0.00	0.0	na	0	0.69	506	0.0	0	0	Baseline
23-Mar	65	607	1-5	4.8	9.0	4.7	8.8	299	19	36	134	2431	153	2,3	4.40	401	0.546	13	22	1.7	na	0.56	14.8	14.8	4	0.58	425	15.9	0	0	Levels 2 (11 inj) & 3 (4 inj)
23-Mar	66	607	1-5	4.8	9.0	4.7	8.8	299	19	32	119	2191	138	2,3	4.43	421	0.573	12	22	0.0	na	0.56	10.8	18.7	4	0.60	440	13.0	0	0	Reduce Level 3 injs to 2
23-Mar	67	607	1-5	4.8	9.0	4.7	8.8	301	19	33	124	2272	143	2,3	4.45	427	0.581	11	22	1.1	na	0.56	9.7	18.5	4	0.59	433	14.5	0	0	Decrease Air to Zone 3
23-Mar	68	607	1-5	4.8	9.0	4.7	8.8	0	0	0	0	0	0	na	4.30	496	0.676	4	18	0.0	D	0.00	-6.2	-1.6	0	0.72	528	-4.3	0	0	Baseline repeat
23-Mar	69	607	1-5	4.8	9.0	4.7	8.8	358	23	32	120	2255	142	2,3	4.20	431	0.587	12	22	2.3	na	0.68	7.0	30.5	4	0.60	440	16.7	0	0	Increase Level 3 NSR
23-Mar	70	604	1-5	4.8	9.0	4.6	8.6	448	28	30	115	2270	143	2,3	4.15	419	0.571	12	22	2.9	na	0.86	9.2	22.5	4	0.59	433	18.1	0	0	Increase Level 2 NSR
23-Mar	71	604	1-5	4.8	9.0	4.6	8.6	0	0	0	0	0	0	na	4.15	486	0.662	4	18	0.0	na	0.00	-5.3	-1.8	0	0.72	528	0.0	0	0	Baseline repeat
25-Mar	72	586	1,3,4,5	nr	nr	nr	nr	0	0	0	0	0	0	na	4.88	443	0.604	3	17.5	0.0	na	0.00	0.0	na	0	0.64	469	0.0	0	0	Baseline (4 mills- #2 OOS)
25-Mar	73	587	1,3,4,6	nr	nr	nr	nr	150	9	6	23	515	33	3	4.80	417	0.568	5	18.5	0.2	na	0.31	5.3	8.6	1	nr	nr	nr	0	0	Level 3 (C&F)
25-Mar	74	588	1,3,4,7	nr	nr	nr	nr	148	9	7	27	572	36	3	4.77	419	0.571	5	18	0.0	na	0.31	4.6	14.2	1	nr	nr	nr	0	0	Increase liquid flow
25-Mar	75	589	1,3,4,8	nr	nr	nr	nr	0	0	0	0	0	0	na	4.68	438	0.597	4	18.5	0.0	na	0.00	-0.5	-28.6	1	nr	nr	nr	0	0	Baseline Repeat
25-Mar	76	590	1,3,4,9	nr	nr	nr	nr	0	0	0	0	0	0	na	4.48	490	0.668	5	19	0.0	na	0.00	0.0	na	0	nr	nr	nr	0	0	Baseline (5 mills)
25-Mar	77	610	1-5	4.6	8.6	3.8	7.1	178	11	23	86	1545	97	2	4.38	424	0.577	10	22	2.1	na	0.32	12.9	7.5	3	nr	nr	nr	0	0	Zone 2 (all injs)
25-Mar	78	610	1-5	4.6	8.6	3.8	7.1	298	19	34	127	2314	146	2,3	4.39	416	0.567	11	22.5	2.2	na	0.54	14.6	8.1	4	0.60	440	17.8	0	0	Add Level 3 (C&F)
25-Mar	79	610	1-5	4.6	8.6	3.8	7.1	371	23	40	151	2757	174	2,3	4.45	401	0.546	12	22.5	0.0	na	0.66	18.0	8.3	4	0.57	418	21.9	0	0	Add B&E MNLs
25-Mar	80	610	1-5	4.6	8.6	3.8	7.1	479	30	38	144	2759	174	2,3	4.33	379	0.516	15	24	3.7	P	0.86	21.8	10.3	5	0.54	396	26.0	0	0	Increase NSR - both levels
25-Mar	81	610	1-5	4.6	8.6	3.8	7.1	461	29	40	153	2891	182	2,3	4.45	383	0.522	16	24	4.7	na	0.83	21.7	11.2	5	0.56	411	23.3	0	0	Incr Lvl 2 NSR, decr Lvl 3 NSR
25-Mar	82	610	1-5	4.8	9.0	3.7	6.9	0	0	0	0	0	0	na	4.53	511	0.696	6	15	0.0	na	0.00	-3.9	-2.5	-4	0.73	535	0.0	0	0	Baseline repeat
26-Mar	83	615	1-5	5.6	10.5	4.3	8.0	0	0	0	0	0	0	na	5.28	504	0.686	5	18.5	0.0	na	0.00	0.0	na	0	0.71	521	0.0	0	0	Baseline
26-Mar	84	615	1-5	5.6	10.5	4.3	8.0	481	30	38	143	2743	173	2,3	5.25	340	0.463	20	25.5	3.6	C	0.83	32.4	10.5	7	0.51	374	nr	0	0	repeat test 80, higher boiler O2
26-Mar	85	616	1-5	5.6	10.5	4.3	8.0	0	0	0	0	0	0	na	5.33	497	0.677	5	17	0.0	na	0.00	1.7	-6.4	-2	nr	nr	nr	0	0	Baseline
26-Mar	86	613	1-5	5.5	10.3	4.2	7.8	482	30	37	141	2716	171	2,3	5.25	367	0.500	18	25	5.6	C	0.85	26.0	11.5	8	nr	nr	nr	0	0	decreaseTop,incr bottom nsr
26-Mar	87	370	2-5	2.8	5.2	2.2	4.1	0	0	0	0	0	0	na	7.03	393	0.536	4	21	0.0	na	0.00	0.0	na	0	0.55	403	0.0	0	0	Baseline 370 MW

Date 1999	Test No.	Load MW	Mills In Serv	APH del P: APH 1 in H_2O	APH del P: APH 1 mm Hg	APH del P: APH 2 in H_2O	APH del P: APH 2 mm Hg	SNCR Injection System Operating Data: Urea Flow gph	Urea Flow lpm	Water Flow gpm	Water Flow lpm	Sol'n Flow gph	Sol'n Flow lpm	Injection Levels in Service	Gaseous Emissions Data: O_2 %	NO_x ppmc	NO_x lb/MMBtu	N_2O ppm	CO ppm	NH_3 ppm	NH_3 sample type	Calculated Data: Overall NSR	del NO %	del N_2O/ del NO, %	del CO ppm	CEM Data: NOx #/M	NOx ppmc	dNOx [%]	Economizer Profile Available: NO_x	NH_3	COMMENTS
26-Mar	88	370	2-5	2.8	5.2	2.2	4.1	117	7	11	41	771	49	2	7.48	343	0.467	7	22	0.0	na	0.41	16.2	5.3	1	0.49	359	12.5	0	0	Zone 2 (13inj)
26-Mar	89	370	2-5	2.8	5.2	2.2	4.1	117	7	18	67	1185	75	2	7.53	329	0.448	9	23	3.4	C	0.41	20.0	7.6	2	0.47	345	16.1	0	0	Zone 2 (13inj)
26-Mar	90	340	2-5	2.8	5.2	2.1	3.9	0	0	0	0	0	0	na	7.60	411	0.560	5	14	0.0	na	0.00	0.8	38.8	-7	0.56	411	0.0	0	0	Baseline
26-Mar	91	340	2-5	2.8	5.2	2.1	3.9	108	7	32	122	2034	128	1	7.53	370	0.504	4	17.5	0.0	na	0.41	10.1	1.2	-4	0.51	374	8.9	0	0	Zone 1 (23 inj)
26-Mar	92	340	2-5	2.8	5.2	2.1	3.9	109	7	49	187	3067	194	1	7.58	352	0.480	6	17	0.0	na	0.41	14.7	3.7	-4	0.49	359	12.5	0	0	Increase water flow
27-Mar	93	605	1-5	5.4	10.1	4.8	9.0	0	0	0	0	0	0	0	5.40	482	0.657	3	19.5	0.0	na	0.00	0.0	na	0	0.68	499	0.0	0	0	Baseline
27-Mar	94	606	1-5	5.4	10.1	4.8	9.0	481	30	37	139	2692	170	2,3	5.25	340	0.463	20	24.5	0.0	na	0.89	28.7	13.6	5	0.49	359	27.9	0	0	repeat test 80
27-Mar	95	606	1-5	5.4	10.1	4.8	9.0	479	30	34	129	2522	159	2,3	5.25	343	0.467	21	25.5	5.3	na	0.89	28.0	14.8	6	0.48	352	29.4	0	0	test 80 w/4 zone 2 inj oos
27-Mar	96	606	1-5	5.2	9.7	4.2	7.8	482	30	37	139	2685	169	2,3	5.11	348	0.475	17	25	4.7	P	0.88	27.8	10.1	6	0.47	345	30.9	0	0	repeat test 80
27-Mar	97	606	1-6	5.2	9.7	4.2	7.8	0	0	0	0	0	0	0	5.23	487	0.663	5	19.5	0.0	na	0.00	0.0	na	0	0.69	506	-1.5	0	0	Baseline
27-Mar	98	454	1.2.4,5	3.7	6.9	2.8	5.2	0	0	0	0	0	0	3	6.80	430	0.586	5	16	0.0	na	0.00	1.6	23.7	-1	0.57	418	0.0	0	0	Baseline 450 MW
27-Mar	99	454	1.2.4,5	3.7	6.9	2.8	5.2	96	6	5	19	392	25	3	6.30	374	0.510	8	20	0.0	na	0.27	10.8	12.8	4	0.51	374	10.5	0	0	Mid lance, NSR=.2
27-Mar	100	454	1.2.4,5	3.7	6.9	2.8	5.2	144	9	7	27	566	36	3	6.35	363	0.495	11	20	0.0	na	0.40	13.8	16.9	4	0.49	359	14.0	0	0	Mid/Top Lance, NSR=.3
27-Mar	101	454	1.2.4,5	3.7	6.9	2.8	5.2	286	18	14	51	1100	69	3	6.28	306	0.417	23	23.5	10.6	C	0.80	27.0	20.8	7	0.42	308	26.3	0	0	All Lances. NSR=0.8
27-Mar	102	454	1.2.4,5	3.7	6.9	2.8	5.2	0	0	0	0	0	0	0	6.40	423	0.576	3	16.5	0.0	na	0.00	0.0	na	0	0.58	425	0.0	0	0	Baseline
29-Mar	103	470	1-5	3.5	6.5	2.8	5.2	0	0	0	0	0	0	0	5.75	415	0.565	2	19	0.0	0	0.00	0.0	na	0	0.58	425	0.0	Y	0	Baseline
29-Mar	104	470	1-5	3.5	6.5	2.8	5.2	77	5	18	69	1165	73	2	5.70	371	0.505	7	20.5	0.0	0	0.21	10.2	13.3	2	0.52	381	10.3	Y	0	Level 2
29-Mar	105	470	1-5	3.5	6.5	2.8	5.2	154	10	17	64	1167	74	2	5.68	345	0.470	11	21.5	0.0	0	0.43	16.3	14.9	3	0.48	352	17.2	Y	0	Level 2, increase nsr
29-Mar	106	470	1-5	3.5	6.5	2.8	5.2	155	10	20	76	1360	86	2	5.69	340	0.463	9	22	5.3	C	0.43	17.6	11.7	3	0.48	352	17.2	Y	0	increase H2O
29-Mar	107	470	1-5	3.5	6.5	2.8	5.2	234	15	16	60	1188	75	2	5.60	321	0.437	13	23	7.9	C	0.65	21.7	13.8	4	0.46	337	20.7	Y	0	decrease H2O, incr nsr
29-Mar	108	470	1-5	3.5	6.5	2.8	5.2	0	0	0	0	0	0	0	5.65	414	0.564	5	18.5	0.0	0	0.00	0.0	na	0	0.59	433	-1.7	Y	0	Baseline
29-Mar	109	470	1-5	3.5	6.5	2.8	5.2	299	19	30	113	2092	132	2,3	5.48	284	0.387	22	25	6.4	P	0.83	30.2	16.0	7	0.39	286	33.9	Y	P	0
29-Mar	110	471	1-5	3.5	6.5	2.7	5.0	300	19	30	112	2081	131	2,3	5.48	295	0.401	18	24	6.7	C	0.83	27.7	13.4	6	nr	nr	nr	Y	0	incr nsr to zone 2, decr nsr zone 3
29-Mar	111	471	1-5	3.5	6.5	2.7	5.0	0	0	0	0	0	0	2,3	5.63	424	0.577	3	17.5	0.0	0	0.00	-2.6	16.2	-1	0.58	425	0.0	Y	0	
31-Mar	112	619	1-5	5.2	9.7	4	7.5	0	0	207	784	12420	784	0	4.95	478	0.651	3	18.5	0.0	0	0.00	0.0	na	0	0.68	499	0.0	Y	0	Baseline
31-Mar	113	617	1-5	5.0	9.3	4	7.5	240	15	21	78	1482	93	2	4.55	395	0.538	10	23	0.0	0	0.43	18.0	7.3	5	0.60	440	11.8	Y	0	Zone 2
31-Mar	114	617	1-5	5.0	9.3	4.0	7.5	297	19	20	75	1480	93	2	4.44	395	0.538	10	21.5	5.7	C	0.54	17.5	7.5	4	0.59	433	13.2	0	0	Zone 2, higher Pair
31-Mar	115	617	1-5	5.0	9.3	4.0	7.5	298	19	21	78	1539	97	2	4.46	404	0.551	11	20.5	4.4	C	0.54	15.6	9.9	3	0.60	440	11.8	0	0	bias zone 2 to side walls
31-Mar	116	615	1-5	4.9	9.2	4.0	7.5	0	0	0	0	0	0	0	4.40	477	0.650	4	18	0.0	0	0.00	0.0	na	0	0.69	506	-1.5	0	0	Baseline
31-Mar	117	615	1-5	4.9	9.2	4.0	7.5	241	15	8	32	746	47	3	4.28	431	0.587	9	20	0.0	0	0.44	8.8	14.1	2	0.63	462	8.7	0	0	mid lances w/larger nozzles

Date 1999	Test No.	Load MW	Mills In Serv	APH del P: APH 1 in H_2O	APH 1 mm Hg	APH 2 in H_2O	APH 2 mm Hg	SNCR Injection System Operating Data: Urea Flow gph	Urea Flow lpm	Water Flow gpm	Water Flow lpm	Sol'n Flow gph	Sol'n Flow lpm	Injection Levels in Service	Gaseous Emissions Data: O_2 %	NO_x ppmc	NO_x lb/MMBtu	N_2O ppm	CO ppm	NH_3 ppm	NH_3 sample type	Calculated Data: Overall NSR	del NO %	del N_2O/ del NO, %	del CO ppm	CEM Data: NOx #/M	NOx ppmc	dNOx [%]	Economizer Profile Available: NO_x	NH_3	COMMENTS
31-Mar	118	615	1-5	4.9	9.2	4.0	7.5	294	19	18	69	1396	88	3	4.33	423	0.576	13	20	0.9	D	0.54	10.9	18.4	2	0.62	455	10.1	0	0	top/mid lances
31-Mar	119	615	1-5	4.9	9.2	4.0	7.5	481	30	39	148	2830	179	2,3	4.49	371	0.506	16	20	2.7	C	0.87	22.6	11.8	2	0.52	381	24.6	0	0	zone 2 & top/mid lances
31-Mar	120	615	1-5	4.9	9.2	4.0	7.5	481	30	40	151	2882	182	2,3	4.48	333	0.453	17	25	7.3	C	0.87	30.6	9.7	7	0.49	359	29.0	0	0	lower lance Pair
31-Mar	121	618	1-5	5.0	9.3	4.0	7.5	0	0	0	0	0	0	0	4.77	488	0.665	2	17.5	0.0	0	0.00	0.3		-1	0.00	0	0.0	0	0	Baseline
6-Apr	122	531	1-5	4.2	7.8	3.4	6.4	0	0	0	0	0	0	0	4.85	446	0.608	3	17.5	0.0	na	0.00	0.0	na	0	0.62	455	0.0	Y	N	Baseline
6-Apr	123	531	1-5	4.2	7.8	3.4	6.4	229	14	26	99	1799	113	2	4.75	340	0.463	13	17	9.1	C	0.52	23.3	11.2	-1	0.49	359	21.0	Y	N	Level 2
6-Apr	124	531	1-5	4.2	7.8	3.4	6.4	228	14	27	102	1848	117	2	4.70	357	0.487	11	17.5	5.8	C	0.52	18.9	10.6	0	0.52	381	16.1	Y	N	Level 2, Increase liquid & air P
6-Apr	125	529	1-5	4.3	8.0	3.3	6.2	0	0	0	0	0	0	0	4.63	439	0.598	2	16	0.0	na	0.00	0.0	na	0	0.61	447	0.0	Y	N	Baseline repeat
6-Apr	126	529	1-5	4.3	8.0	3.3	6.2	468	30	43	164	3068	194	2,3	4.68	315	0.430	20	16	8.1	C	1.07	28.4	15.9	0	0.44	323	29.0	Y	N	Levels 2,3
6-Apr	127	528	1-5	4.2	7.8	3.3	6.2	0	0	0	0	0	0	0	4.80	459	0.625	3	16	0.0	na	0.00	0.0	na	0	0.62	455	0.0	Y	N	Baseline repeat
7-Apr	128	600	1-5	5.4	10.1	4.4	8.2	0	0	0	0	0	0	0	5.40	479	0.653	4	12	0.0	na	0.00	0.0	na	-4	0.70	513	0.0	Y	N	Baseline
7-Apr	129	600	1-5	5.4	10.1	4.4	8.2	90	6	8	29	551	35	2	5.28	448	0.610	7	12	0.0	na	0.17	5.6	10.9	-4	0.65	477	7.1	Y	N	Level 2 sidewalls only
7-Apr	130	600	1-5	5.4	10.1	4.4	8.2	180	11	26	97	1725	109	2	5.18	424	0.578	10	12	2.4	C	0.34	10.0	13.2	-4	0.61	447	12.9	Y	N	Level 2 all,bias to sidewall
7-Apr	131	600	1-5	5.4	10.1	4.4	8.2	270	17	25	94	1755	111	2	5.03	409	0.557	12	13.5	4.0	C	0.52	12.3	14.7	0	0.60	440	14.3	Y	N	Level 2 all,bias to sidewall
7-Apr	132	600	1-5	5.4	10.1	4.4	8.2	449	28	41	155	2904	183	2,3	4.83	356	0.485	17	17	4.2	C	0.87	22.3	14.0	0	0.51	374	27.1	Y	N	incr nsr
7-Apr	133	611	1-5	5.3	9.9	4.3	8.0	480	30	40	151	2872	181	2,3	4.73	349	0.476	19	17	4.3	C	0.92	23.2	15.1	0	0.51	374	27.1	Y	N	bal zone 2 inj, incr sidewall Pair
7-Apr	134	611	1-5	5.3	9.9	4.3	8.0	0	0	0	0	0	0	0	4.88	483	0.658	4	15	0.0	na	0.00	0.0	na	0	0.70	513	0.0	Y	N	Baseline
7-Apr	135	611	1-5	5.3	9.9	4.3	8.0	554	35	41	156	3020	191	2,3	4.88	343	0.467	19	17	3.9	C	1.00	29.0	12.0	2	0.51	374	28.2	Y	N	incr zone 3 nsr& H2O
7-Apr	136	611	1-5	5.3	9.9	4.3	8.0	0	0	0	0	0	0	0	4.93	490	0.668	5	15	0.0	na	0.00	-1.1		-2	0.71	521	-1.4	Y	N	Baseline
8-Apr	137	618	1-5	5.2	9.7	4.3	8.0	0	0	0	0	0	0	0	4.43	478	0.651	4	20	0.0	D	0.00	0.0	11.2	3	0.71	521	0.0	Y	N	Baseline, unit regulating
9-Apr	138	611	1-5	5.2	9.7	4.2	7.8	0	0	0	0	0	0	0	4.50	469	0.639	4	21.5	0.0	na	0.00	0.0	na	0	0.67	491	0.0	Y	N	Baseline
9-Apr	139	611	1-5	5.2	9.7	4.2	7.8	532	34	42	159	3053	193	2,3	4.53	322	0.439	22	28.5	0.0	C	0.99	31.5	13.6	7	0.46	337	31.3	Y	N	Zones 2&3, NH3 traverse
9-Apr	139A1	611	1-5	5.2	9.7	4.2	7.8	532	34	42	159	3053	193	2,3	4.55	335	0.457	21	25	0.0	T	0.99	28.8	14.1	4	0.48	352	28.4	Y	Y	Zones 2&3, NH3 traverse
9-Apr	139A2	617	1-5	5.3	9.9	4.2	7.8	562	35	41	157	3046	192	2,3	4.85	337	0.459	21	25	0.0	C	1.01	30.0	13.5	4	0.48	352	28.4	Y	N	Zones 2&3, NH3 traverse
9-Apr	139A3	617	1-5	5.3	9.9	4.2	7.8	562	35	41	157	3046	192	2,3	4.68	331	0.451	24	25	0.0	C	1.02	30.5	15.2	4	0.49	359	30.0	Y	N	Zones 2&3, NH3 traverse
9-Apr	139A4	611	1-5	5.5	10.3	4.3	8.0	589	37	41	156	3063	193	2,3	4.75	343	0.468	23	25	0.0	na	1.08	28.2	15.6	4	0.49	359	30.0	Y	N	Zones 2&3, NH3 traverse
9-Apr	140	611	1-5	5.5	10.3	4.3	8.0	0	0	0	0	0	0	0	4.63	489	0.667	6	20	0.0	na	0.00	0.0	0.0	0	0.70	513	0.0	Y	N	Baseline
9-Apr	141	611	1-5	5.5	10.3	4.3	8.0	574	36	40	152	2983	188	2,3	4.50	340	0.463	12	25	0.0	na	1.03	29.9	4.6	5	0.46	337	34.3	Y	N	Bias lance injectors(north/south)
9-Apr	142	611	1-5	5.5	10.3	4.3	8.0	574	36	40	150	2951	186	2,3	4.58	312	0.425	27	27	0.0	na	1.09	32.1	14.6	10	0.43	315	35.8	Y	N	Bias lance injectors(north/south)

Date 1999	Test No.	Load MW	Mills In Serv	APH del P: APH 1 in H_2O	APH 1 mm Hg	APH 2 in H_2O	APH 2 mm Hg	SNCR Injection System Operating Data: Urea Flow gph	Urea Flow lpm	Water Flow gpm	Water Flow lpm	Sol'n Flow gph	Sol'n Flow lpm	Injection Levels in Service	Gaseous Emissions Data: O_2 %	NO_x ppmc	NO_x lb/MMBtu	N_2O ppm	CO ppm	NH_3 ppm	NH_3 sample type	Calculated Data: Overall NSR	del NO %	del N_2O/ del NO, %	del CO ppm	CEM Data: NOx #/M	NOx ppmc	dNOx [%]	Economizer Profile Available: NO_x	NH_3	COMMENTS
9-Apr	143	611	1-5	5.5	10.3	4.3	8.0	0	0	0	0	0	0	0	4.78	467	0.636	7	17	0.0	na	0.00	0.0	0.0	0	0.67	491	0.0	Y	N	Baseline
10-Apr	144	353	1,3-5	3.1	5.8	2.1	3.9	0	0	0	0	0	0	0	7.64	383	0.522	4	17.5	0.0	0	0.00	0.0	0.0	0	0.58	425	0.0	0	N	Baseline
10-Apr	145	353	1,3-5	3.1	5.8	2.1	3.9	118	7	53	199	3275	207	1	7.50	336	0.457	6	19	0.0	0	0.47	11.2	7.3	2	0.49	359	15.5	0	N	zone 1 all
10-Apr	146	353	1,3-5	3.1	5.8	2.1	3.9	240	15	51	192	3280	207	1	7.48	302	0.411	8	20.5	0.0	0	0.96	20.0	8.5	3	0.43	315	25.9	0	N	zone 1 all, incr nsr
10-Apr	147	353	1,3-5	3.1	5.8	2.1	3.9	61	4	13	50	847	53	1	7.58	360	0.491	4	18.5	0.0	0	0.24	5.4	3.5	1	0.52	381	10.3	0	N	zone 1 rear
10-Apr	148	353	1,3-5	3.1	5.8	2.1	3.9	95	6	17	65	1128	71	1	7.58	370	0.504	4	18.5	0.0	0	0.38	2.9	7.1	1	0.52	381	11.9	0	N	zone1 sides
10-Apr	149	353	1,3-5	3.1	5.8	2.1	3.9	0	0	0	0	0	0	0	7.75	405	0.551	2	17	0.0	0	0.00	0.0	0.0	-1	0.59	433	0.0	0	N	Baseline
10-Apr	150	353	1,3-5	3.1	5.8	2.1	3.9	97	6	19	71	1222	77	1	7.60	364	0.497	4	18	0.0	0	0.37	8.7	5.7	-4	0.54	396	8.5	0	N	zone 1 front
10-Apr	151	353	1,3-5	3.1	5.8	2.1	3.9	152	10	46	175	2924	184	1,2	7.53	212	0.289	14	17.5	0.0	0	0.58	46.5	8.1	-4	0.37	271	37.3	0	N	zones1 &2
10-Apr	152	353	1,3-5	3.1	5.8	2.1	3.9	na	na	na	na	na	ma	na	nr	nr	na	nr	nr	nr	na	na	na	na	nr	0.00	0	0.0	nr	nr	test aborted, broken hose
10-Apr	153	353	1,3-5	3.1	5.8	2.1	3.9	54	3	6	24	442	28	2	7.65	370	0.505	5	17.5	0.0	0	0.20	7.6	10.7	-4	0.53	389	10.2	0	N	zone 2 sides
10-Apr	154	353	1,3-5	3.1	5.8	2.1	3.9	101	6	16	59	1036	65	2	7.50	337	0.459	10	19	0.0	0	0.39	14.8	15.1	-3	0.50	367	13.8	0	N	zone 2 front
10-Apr	155	353	1,3-5	3.1	5.8	2.1	3.9	0	0	0	0	0	0	0	7.53	404	0.550	4	17	0.0	0	0.00	-1.8	-16.9	-5	0.58	425	0.0	0	N	Baseline
12-Apr	156	343	1,2,4,5	3.2	6.0	2.2	4.1	0	0	0	0	0	0	0	8.00	401	0.547	3	18	0.0	0	0.00	0.0	na	0	0.54	396	0.0	Y	0	Baseline
12-Apr	157	343	1,2,4,5	3.2	6.0	2.2	4.1	150	9	23	86	1506	95	2	8.05	297	0.405	14	22	8.1	C	0.58	26.3	15.6	4	0.42	308	22.2	Y	0	Level 2
12-Apr	158	343	1,2,4,5	3.2	6.0	2.2	4.1	224	14	21	81	1508	95	2	8.08	266	0.363	17	24.5	18.2	C	0.86	34.1	14.5	7	0.43	315	20.4	Y	0	Level 2,incr nsr
12-Apr	159	343	1,2,4,5	3.2	6.0	2.2	4.1	222	14	23	87	1596	101	2	8.23	262	0.356	17	25	18.3	C	0.84	36.1	14.1	7	0.42	308	22.2	Y	0	Level 2,incr nsr,incr Pair
12-Apr	160	343	1,2,4,5	3.2	6.0	2.2	4.1	300	19	21	78	1530	97	2	8.30	236	0.322	21	27.5	31.2	C	1.13	42.7	14.9	10	0.39	286	35.5	Y	0	Level 2,inr nsr, orig Pair
12-Apr	161	343	1,2,4,5	3.2	6.0	2.2	4.1	0	0	0	0	0	0	0	8.30	416	0.566	3	17	0.0	0	0.00	0.0	na	-1	0.61	444	0.0	Y	0	Baseline
12-Apr	162	343	1,2,4,5	3.2	6.0	2.2	4.1	150	9	7	26	558	35	2	8.10	345	0.470	5	20	1.3	C	0.58	14.8	5.9	2	0.46	337	24.0	Y	P	Level 2 test 157 w lower H2O
12-Apr	163	340	1,2,4,6	3.3	6.2	2.3	4.3	109	7	12	44	799	50	3	8.10	325	0.443	18	27	9.4	C	0.42	19.6	26.4	9	0.46	337	24.0	Y	0	Level 3 top /mid lances
12-Apr	164	340	1,2,4,7	3.3	6.2	2.3	4.3	109	7	5	18	395	25	3	8.08	349	0.476	15	23.5	15.1	C	0.42	13.5	30.6	6	0.49	359	19.0	Y	0	#REF!
12-Apr	165	340	1,2,4,8	3.3	6.2	2.3	4.3	120	8	53	199	3273	206	1	7.93	326	0.444	8	20.5	2.2	C	0.45	22.5	7.4	2	0.46	337	23.3	Y	0	Level 3 mid lances
12-Apr	166	340	1,2,4,9	3.3	6.2	2.3	4.3	0	0	0	0	0	0	0	7.68	411	0.560	3	18.5	0.0	0	0.00	0.0	na	0	0.60	440	0.0	Y	0	Baseline
20-Apr	167	nr	nr	nr	nr	nr	nr	0	0	0	0	0	0	0	0.00	0	0.000	0	0	0.0	0	0.00	0.0	0.0	0	0	0	0.0	0	0	Baseline, no injection tests
21-Apr	168	573	1-5	4.9	9.2	3.8	7.1	0	0	0	0	0	0	0	4.95	466	0.634	2	17	0.0	0	0.00	0.0	na	0	0.69	506	0.0	Y	0	Baseline
21-Apr	169	573	1-5	4.9	9.2	3.8	7.1	241	15	16	59	1180	74	2	4.88	416	0.567	7	17	0.0	0	0.48	10.2	12.4	0	0.63	462	8.7	Y	0	zone 2
21-Apr	170	573	1-5	4.9	9.2	3.8	7.1	239	15	19	71	1358	86	2	4.78	408	0.556	9	17	0.0	0	0.48	11.2	14.9	0	0.62	455	10.1	Y	0	zone 2, higher H2O
21-Apr	171	573	1-5	4.9	9.2	3.8	7.1	239	15	22	82	1535	97	2	4.70	408	0.555	9	17	5.0	D	0.49	10.8	17.0	0	0.60	440	13.0	Y	0	zone 2 Higher H2O
21-Apr	172	573	1-5	4.9	9.2	3.8	7.1	478	30	38	143	2742	173	2,3	4.53	327	0.445	17	22	7.8	P(mid)	0.99	27.5	13.7	5	0.49	359	29.0	Y	0	zones 2&3, small bias

Date 1999	Test No.	Load MW	Mills In Serv	APH del P: APH 1 in H_2O	APH del P: APH 1 mm Hg	APH del P: APH 2 in H_2O	APH del P: APH 2 mm Hg	SNCR Injection System Operating Data: Urea Flow gph	Urea Flow lpm	Water Flow gpm	Water Flow lpm	Sol'n Flow gph	Sol'n Flow lpm	Injection Levels in Service	Gaseous Emissions Data: O_2 %	NO_x ppmc	NO_x lb/MMBtu	N_2O ppm	CO ppm	NH_3 ppm	NH_3 sample type	Calculated Data: Overall NSR	del NO %	del N_2O/ del NO, %	del CO ppm	CEM Data: NOx #/M	NOx ppmc	dNOx [%]	Economizer Profile Available: NO_x	NH_3	COMMENTS
21-Apr	173	573	1-5	4.9	9.2	3.8	7.1	478	30	37	138	2670	168	0	4.53	329	0.448	14	23	6.7	P(mid)	0.99	27.0	10.9	6	0.49	359	29.0	Y	0	zones 2&3, small bias
21-Apr	174	573	1-5	4.9	9.2	3.8	7.1	481	30	35	131	2555	161	0	4.53	336	0.458	14	23	0.0	0	0.99	25.4	11.7	6	0.50	367	27.5	Y	0	zones 2&3, bias from wall (25%)
21-Apr	175	575	1-5	4.8	9.0	3.8	7.1	480	30	33	125	2465	156	0	4.48	337	0.459	13	23	0.0	P(v+h)	0.99	25.0	10.7	6	0.49	359	29.0	Y	0	zones 2&3, small bias
21-Apr	176	575	1-5	4.8	9.0	3.8	7.1	0	0	0	0	0	0	0	4.53	431	0.587	4	16.5	0.0	0	0.00	4.3	0.0	0	0.64	469	7.2	Y	0	Baseline
22-Apr	177	453	1,2,4,5	4.2	7.8	3.2	6.0	0	0	0	0	0	0	na	7.03	458	0.623	2	15	0.0	0	0.00	0.0	0.0	0	0.67	491	0.0	Y	0	Baseline
22-Apr	178	453	1,2,4,5	4.2	7.8	3.2	6.0	167	11	9	35	727	46	1	7.03	387	0.527	6	17	0.0	0	0.43	15.5	6.4	2	0.57	418	14.9	N	0	Level 1, rear wall
22-Apr	179	453	1,2,4,5	4.2	7.8	3.2	6.0	304	19	14	52	1132	71	1	6.88	376	0.513	6	18	0.0	0	0.79	16.8	6.7	3	0.55	403	17.9	Y	0	Level 1, rear wall + 5 front wall
22-Apr	180	453	1,2,4,5	4.2	7.8	3.2	6.0	341	22	19	73	1490	94	1,2	6.90	355	0.483	8	18	0.0	0	0.89	21.8	7.2	3	0.51	374	23.9	Y	0	Zone1 (rear)+ zone 2
22-Apr	181	457	1,2,4,5	4.1	7.7	3.3	6.2	340	21	23	85	1691	107	1,2	6.88	342	0.467	9	19	0.0	0	0.88	24.3	8.3	4	0.50	367	25.4	Y	0	Zone1 (rear)+ zone 3, higher H2O
22-Apr	182	457	1,2,4,5	4.1	7.7	3.3	6.2	341	22	26	97	1885	119	1,2	6.80	337	0.460	10	19	0.0	0	0.89	25.0	9.0	4	0.49	356	27.6	Y	0	Vary liquid flow
22-Apr	183	457	1,2,4,5	4.1	7.7	3.3	6.2	340	21	40	151	2731	172	1,2	6.88	322	0.439	16	22	4.6	C	0.88	28.8	13.7	7	0.45	330	32.8	Y	0	Add zone 3
22-Apr	184	457	1,2,4,5	4.1	7.7	3.3	6.2	329	21	40	152	2739	173	1,2,3,	6.75	307	0.418	21	23	6.5	C	0.86	31.5	16.6	8	0.43	315	35.8	Y	0	0
22-Apr	185	457	1,2,4,5	4.1	7.7	3.3	6.2	0	0	0	0	0	0	0	6.79	463	0.630	1	15	0.0	C	0.00	0.0	0.0	0	0.66	484	1.5	Y	0	Baseline
22-Apr	186	457	1,2,4,5	4.1	7.7	3.3	6.2	322	20	36	136	2474	156	1,2,3,	6.75	288	0.392	21	22.5	6.9	C	0.82	37.6	14.6	8	0.40	293	39.4	Y	0	0
22-Apr	187	457	1,2,4,5	4.1	7.7	3.3	6.2	289	18	36	138	2477	156	1,2,3,	6.70	300	0.409	20	22.5	6.0	C	0.74	34.6	14.8	8	0.43	315	34.8	Y	0	0
22-Apr	188	457	1,2,4,5	4.1	7.7	3.3	6.2	0	0	0	0	0	0	0	6.77	462	0.629	2	17	0.0	0	0.00	0.0	0.0	2	0.65	477	3.0	Y	0	Baseline
23-Apr	189	450	1-5	4.3	8.0	3.2	6.0	0	0	0	0	0	0	0	6.95	426	0.580	3	15	0.0	0	0.00	0.0	0.0	0	0.61	447	0.0	Y	0	Baseline
23-Apr	190	450	1-5	4.3	8.0	3.2	6.0	154	10	9	36	719	45	1	6.60	346	0.472	2	16.5	0.5	0	0.44	16.2	-2.0	2	0.50	367	18.0	Y	0	Zone 1
23-Apr	191	450	1-5	4.3	8.0	3.2	6.0	229	14	24	92	1685	106	1,2	6.55	315	0.429	10	18	1.2	0	0.66	23.6	8.9	3	0.47	345	23.0	Y	0	Zones 1&2
23-Apr	192	450	1-5	4.3	8.0	3.2	6.0	322	20	36	136	2484	157	1,2,3	6.45	288	0.393	14	20	2.7	0	0.93	29.3	10.8	5	0.40	293	34.4	Y	0	Zones 1,2,3,
23-Apr	193	450	1-5	4.3	8.0	3.2	6.0	270	17	36	138	2458	155	1,2,3	6.45	283	0.385	17	20	3.4	P(1-6,7-12)	0.79	30.7	13.3	5	0.40	293	34.4	Y	0	Zones 1,2,3,
23-Apr	194	450	1-5	4.3	8.0	3.2	6.0	0	0	0	0	0	0	0	6.55	417	0.568	1	20	0.0	0	0.00	-1.3	0.0	5	0.60	440	1.6	Y	0	Baseline
23-Apr	195	335	1,2,4,5	2.8	5.2	2.3	4.3	0	0	0	0	0	0	0	7.80	389	0.530	2	15	0.0	0	0.00	0.0	0.0	0	0.55	403	0.0	Y	0	Baseline
23-Apr	196	335	1,2,4,5	2.8	5.2	2.3	4.3	109	7	9	33	625	39	1	7.80	321	0.437	9	20	0.0	0	0.44	17.6	14.0	5	0.46	337	16.4	Y	0	Zone 1 rear wall
23-Apr	197	335	1,2,4,5	2.8	5.2	2.3	4.3	109	7	35	134	2235	141	1	7.70	325	0.443	8	20	0.0	0	0.45	15.7	13.4	5	0.47	345	14.5	Y	0	Zone 1 all 23
23-Apr	198	335	1,2,4,5	2.8	5.2	2.3	4.3	159	10	23	85	1513	95	1	7.80	307	0.419	11	20	0.0	0	0.65	21.0	15.8	5	0.43	315	21.8	Y	0	Zone 1 front, rear
24-Apr	199	340	1,2,4,5	3.2	6.0	2.3	4.3	0	0	0	0	0	0	0	8.00	400	0.545	3	15	0.0	0	0.00	0.0	0.0	0	0.58	425	0.0	Y	0	Baseline 3mill oos,#4mill biased down
24-Apr	200	340	1,2,4,5	3.2	6.0	2.3	4.3	148	9	23	87	1525	96	1	8.10	307	0.418	10	20	0.0	0	0.57	24.0	9.4	5	0.43	315	25.9	Y	0	Zone 1
24-Apr	201	340	1,2,4,5	3.2	6.0	2.3	4.3	203	13	34	129	2245	142	1,2	8.05	257	0.351	15	20	2.0	0	0.79	35.9	11.1	5	0.38	279	34.5	Y	0	Zones 1&2
24-Apr	202	340	1,2,4,5	3.2	6.0	2.3	4.3	207	13	34	127	2225	140	1,2	8.20	277	0.377	13	20	2.4	0	0.80	32.0	10.3	5	0.39	286	32.8	Y	0	Zones 1&2, nsr1-,nsr2+

Date 1999	Test No.	Load MW	Mills In Serv	APH del P: APH 1 in H_2O	APH 1 mm Hg	APH 2 in H_2O	APH 2 mm Hg	SNCR Injection System Operating Data: Urea Flow gph	Urea Flow lpm	Water Flow gpm	Water Flow lpm	Sol'n Flow gph	Sol'n Flow lpm	Injection Levels in Service	Gaseous Emissions Data: O_2 %	NO_x ppmc	NO_x lb/MMBtu	N_2O ppm	CO ppm	NH_3 ppm	NH_3 sample type	Calculated Data: Overall NSR	del NO %	del N_2O/ del NO, %	del CO ppm	CEM Data: NOx #/M	NOx ppmc	dNOx [%]	Economizer Profile Available: NO_x	NH_3	COMMENTS
24-Apr	203	340	1,2,4,5	3.2	6.0	2.3	4.3	209	13	44	167	2849	180	1,2,3	8.20	263	0.358	16	20	7.6	0	0.81	35.5	12.2	5	0.38	279	34.5	Y	0	Zones 1,2,3,
24-Apr	204	340	1,2,4,5	3.2	6.0	2.3	4.3	0	0	0	0	0	0	0	8.40	424	0.578	3	15	0.0	0	0.00	-2.4	5.9	0	0.62	455	0.0	Y	0	Baseline
24-Apr	205	340	1,2,4,5	3.2	6.0	2.3	4.3	152	10	32	120	2051	129	1,3	8.30	306	0.418	14	20	0.0	0	0.58	25.4	14.4	5	0.44	323	29.0	Y	0	Zones 1&3
24-Apr	206	340	1,2,4,5	3.2	6.0	2.3	4.3	216	14	33	127	2223	140	1,2	8.25	275	0.375	12	20	0.0	0	0.83	32.7	9.0	5	0.41	301	33.9	Y	0	Zones 1&2
24-Apr	207	340	1,2,4,5	3.2	6.0	2.3	4.3	256	16	33	124	2225	140	1,2	8.35	260	0.354	15	20	0.0	0	0.98	36.9	10.8	5	0.38	279	38.7	Y	0	Zones 1&2,incr nsr1
24-Apr	208	340	1,2,4,5	3.2	6.0	2.3	4.3	312	20	32	122	2251	142	1,2	8.30	245	0.333	17	20	0.0	0	1.19	40.4	12.0	5	0.36	264	41.9	Y	0	Zones 1&2,incr nsr1, incr nsr2
24-Apr	209	340	1,2,4,5	3.2	6.0	2.3	4.3	0	0	0	0	0	0	0	8.40	421	0.573	2	15	0.0	0	0.00	-1.6	20.1	0	0.60	440	3.2	Y	0	0
26-Apr	210	618	1-5	5.3	9.9	4.3	8.0	0	0	0	0	0	0	0	4.95	476	0.649	4	17.5	0.0	0	0.00	0.0	na	0	0.72	528	0.0	Y	0	Baseline
26-Apr	211	618	1-5	5.3	9.9	4.3	8.0	227	14	40	151	2621	165	2,3	4.88	418	0.569	12	21.5	0.0	0	0.41	11.8	16.3	4	0.60	440	16.7	Y	0	Zones 2,3
26-Apr	212	618	1-5	5.3	9.9	4.3	8.0	346	22	39	147	2682	169	2,3	4.73	395	0.538	15	23.5	4.1	C	0.64	15.6	16.4	6	0.57	418	20.8	Y	C	Increase NSR
26-Apr	213	618	1-5	5.3	9.9	4.3	8.0	346	22	38	144	2626	166	2,3	4.72	385	0.525	14	22	3.8	C	0.64	17.6	13.3	5	0.59	433	18.1	Y	C	Increase nsr&H2O to mid lances
26-Apr	214	618	1-5	5.3	9.9	4.3	8.0	455	29	36	138	2644	167	2,3	4.70	372	0.507	17	25	4.2	C	0.84	20.4	15.3	8	0.55	403	23.6	Y	C	Increase NSR
26-Apr	215	618	1-5	5.3	9.9	4.3	8.0	0	0	0	0	0	0	0	4.80	494	0.673	4	18	0.0	0	0.00	0.0	na	0	0.73	535	-1.4	Y	0	Baseline
26-Apr	216	618	1-5	5.3	9.9	4.3	8.0	456	29	40	151	2847	180	2,3	4.60	374	0.510	18	25.5	5.5	C	0.81	23.1	13.6	8	0.55	403	24.7	Y	C	increase H2O
26-Apr	217	618	1-5	5.3	9.9	4.3	8.0	546	34	39	146	2856	180	2,3	2.43	159	0.217	12	13.5	10.5	P	1.15	30.5	3.2	-5	nr	nr	na	Y	C	Test aborted, lost mill
27-Apr	218	408	1-3,5	4.5	8.4	3.7	6.9	0	0	0	0	0	0	0	7.13	379	0.516	1	20	0.0	0	0.00	0.0	na	0	0.54	396	0.0	Y	0	Baseline
27-Apr	219	408	1-3,5	4.5	8.4	3.7	6.9	149	9	10	36	725	46	1	6.98	313	0.427	7	21	0.0	0	0.52	16.1	11.7	1	0.45	330	16.7	Y	0	Baseline
27-Apr	220	408	1-3,5	4.5	8.4	3.7	6.9	151	10	24	90	1574	99	1	6.90	322	0.439	7	21.5	0.0	0	0.53	13.1	14.4	2	0.46	337	14.8	Y	0	Zones 1&2
27-Apr	221	408	1-3,5	4.5	8.4	3.7	6.9	252	16	37	139	2461	155	1,2	6.95	281	0.383	10	22.5	1.9	0	0.88	24.7	12.5	3	0.41	301	24.1	0	0	Zones 1&2 incr nsr
27-Apr	222	408	1-3,5	4.5	8.4	3.7	6.9	276	17	38	142	2533	160	1,2	6.79	272	0.371	16	23.5	3.1	0	0.98	25.8	20.1	4	0.39	286	27.8	0	0	Zones 1&2 incr nsr Z2,decr Z1
27-Apr	223	408	1-3,5	4.5	8.4	3.7	6.9	280	18	49	184	3190	201	1,2,3	6.85	239	0.325	21	26	6.2	0	0.99	35.4	19.0	6	0.34	249	37.0	0	0	Zones 1,2&3
27-Apr	224	408	1-3,5	4.5	8.4	3.7	6.9	253	16	49	185	3178	200	1,2,3	6.43	214	0.291	22	26.5	6.5	0	0.93	39.6	18.4	7	0.32	235	40.7	0	0	Zones 1,2&3
27-Apr	225	408	1-3,5	4.5	8.4	3.7	6.9	253	16	35	132	2342	148	1,2,3	6.53	221	0.301	20	26	0.0	D	0.92	38.3	17.2	6	0.33	242	38.9	0	0	Zones 1,2&3, decr H2O
27-Apr	226	408	1-3,5	4.5	8.4	3.7	6.9	0	0	0	0	0	0	0	6.65	371	0.505	2	18.5	0.0	D	0.00	-2.4	-3.1	-2	nr	nr	0.0	0	0	Baseline

B
OPTIMIZATION DATA - SORTED BY LOAD

Optimization Data - Sorted by Load

Date 1999	Test No.	Load MW	Mills In Serv	APH del P: APH 1 in H_2O	APH 1 mm Hg	APH 2 in H_2O	APH 2 mm Hg	SNCR Injection System Operating Data: Urea Flow gph	Urea Flow lpm	Water Flow gpm	Water Flow lpm	Sol'n Flow gph	Sol'n Flow lpm	Injection Levels in Service	Gaseous Emissions Data: O_2 %	NO_x ppmc	NO_x lb/MMBtu	N_2O ppm	CO ppm	NH_3 ppm	NH_3 sample type	Calculated Data: Overall NSR	del NO %	del N_2O/ del NO, %	del CO ppm	CEM Data: NOx #/M	NOx ppmc	dNOx [%]	Economizer Profile Available: NO_x	NH_3	COMMENTS
31-Mar	112	619	1-5	5.2	9.7	4	7.5	0	0	207	784	12420	784	0	4.95	478	0.651	3	18.5	0.0	0	0.00	0.0	na	0	0.68	499	0.0	Y	0	Baseline
31-Mar	121	618	1-5	5.0	9.3	4.0	7.5	0	0	0	0	0	0	0	4.77	488	0.665	2	17.5	0.0	0	0.00	0.3		-1	0.00	0	0.0	0	0	Baseline
8-Apr	137	618	1-5	5.2	9.7	4.3	8.0	0	0	0	0	0	0	0	4.43	478	0.651	4	20	0.0	D	0.00	0.0	11.2	3	0.71	521	0.0	Y	N	Baseline, unit regulating
26-Apr	210	618	1-5	5.3	9.9	4.3	8.0	0	0	0	0	0	0	0	4.95	476	0.649	4	17.5	0.0	0	0.00	0.0	na	0	0.72	528	0.0	Y	0	Baseline
26-Apr	211	618	1-5	5.3	9.9	4.3	8.0	227	14	40	151	2621	165	2,3	4.88	418	0.569	12	21.5	0.0	0	0.41	11.8	16.3	4	0.60	440	16.7	Y	0	Zones 2,3
26-Apr	212	618	1-5	5.3	9.9	4.3	8.0	346	22	39	147	2682	169	2,3	4.73	395	0.538	15	23.5	4.1	C	0.64	15.6	16.4	6	0.57	418	20.8	Y	C	Increase NSR
26-Apr	213	618	1-5	5.3	9.9	4.3	8.0	346	22	38	144	2626	166	2,3	4.72	385	0.525	14	22	3.8	C	0.64	17.6	13.3	5	0.59	433	18.1	Y	C	Increase nsr&H2O to mid lances
26-Apr	214	618	1-5	5.3	9.9	4.3	8.0	455	29	36	138	2644	167	2,3	4.70	372	0.507	17	25	4.2	C	0.84	20.4	15.3	8	0.55	403	23.6	Y	C	Increase NSR
26-Apr	215	618	1-5	5.3	9.9	4.3	8.0	0	0	0	0	0	0	0	4.80	494	0.673	4	18	0.0	0	0.00	0.0	na	0	0.73	535	-1.4	Y	0	Baseline
26-Apr	216	618	1-5	5.3	9.9	4.3	8.0	456	29	40	151	2847	180	2,3	4.60	374	0.510	18	25.5	5.5	C	0.81	23.1	13.6	8	0.55	403	24.7	Y	C	increase H2O
26-Apr	217	618	1-5	5.3	9.9	4.3	8.0	546	34	39	146	2856	180	2,3	2.43	159	0.217	12	13.5	10.5	P	1.15	30.5	3.2	-5	nr	nr	na	Y	C	Test aborted, lost mill
31-Mar	113	617	1-5	5.0	9.3	4	7.5	240	15	21	78	1482	93	2	4.55	395	0.538	10	23	0.0	0	0.43	18.0	7.3	5	0.60	440	11.8	Y	0	Zone 2
31-Mar	114	617	1-5	5.0	9.3	4.0	7.5	297	19	20	75	1480	93	2	4.44	395	0.538	10	21.5	5.7	C	0.54	17.5	7.5	4	0.59	433	13.2	0	0	Zone 2, higher Pair
31-Mar	115	617	1-5	5.0	9.3	4.0	7.5	298	19	21	78	1539	97	2	4.46	404	0.551	11	20.5	4.4	C	0.54	15.6	9.9	3	0.60	440	11.8	0	0	bias zone 2 to side walls
9-Apr	139A2	617	1-5	5.3	9.9	4.2	7.8	562	35	41	157	3046	192	2,3	4.85	337	0.459	21	25	0.0	C	1.01	30.0	13.5	4	0.48	352	28.4	Y	N	Zones 2&3, NH3 traverse
9-Apr	139A3	617	1-5	5.3	9.9	4.2	7.8	562	35	41	157	3046	192	2,3	4.68	331	0.451	24	25	0.0	C	1.02	30.5	15.2	4	0.49	359	30.0	Y	N	Zones 2&3, NH3 traverse
16-Mar	4	616	1-5	5.0	9.3	4.2	7.8	0	0	0	0	0	0	na	4.85	513	0.699	17	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	Baseline
16-Mar	5	616	1-5	5.0	9.3	4.2	7.8	510	32	30	114	2321	146	2,3	4.55	463	0.630	25	22	0.0	na	0.88	7.9	19.3	2	nr	nr	nr	Y	N	Levels 2,3
16-Mar	6	616	1-5	5.0	9.3	4.2	7.8	510	32	30	114	2321	146	2,3	4.60	414	0.565	29	25	0.0	na	0.88	17.8	14.7	5	nr	nr	nr	Y	N	Decr Zone 3 Liquid
16-Mar	7	616	1-5	5.0	9.3	4.2	7.8	0	0	0	0	0	0	na	4.53	497	0.677	22	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	BL Repeat
26-Mar	85	616	1-5	5.6	10.5	4.3	8.0	0	0	0	0	0	0	na	5.33	497	0.677	5	17	0.0	na	0.00	1.7	-6.4	-2	nr	nr	nr	0	0	Baseline
16-Mar	8	615	1-5	4.8	9.0	3.7	6.9	510	32	34	129	2549	161	2,3	4.38	440	0.599	40	23	1.8	P	0.90	10.5	38.1	3	nr	nr	nr	Y	P	Incr Zone 2 Liquid
16-Mar	9	615	1-5	4.8	9.0	3.7	6.9	0	0	0	0	0	0	na	4.68	529	0.721	31	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	BL Repeat
26-Mar	83	615	1-5	5.6	10.5	4.3	8.0	0	0	0	0	0	0	na	5.28	504	0.686	5	18.5	0.0	na	0.00	0.0	na	0	0.71	521	0.0	0	0	Baseline
26-Mar	84	615	1-5	5.6	10.5	4.3	8.0	481	30	38	143	2743	173	2,3	5.25	340	0.463	20	25.5	3.6	C	0.83	32.4	10.5	7	0.51	374	nr	0	0	repeat test 80, higher boiler O2
31-Mar	116	615	1-5	4.9	9.2	4.0	7.5	0	0	0	0	0	0	0	4.40	477	0.650	4	18	0.0	0	0.00	0.0	na	0	0.69	506	-1.5	0	0	Baseline
31-Mar	117	615	1-5	4.9	9.2	4.0	7.5	241	15	8	32	746	47	3	4.28	431	0.587	9	20	0.0	0	0.44	8.8	14.1	2	0.63	462	8.7	0	0	mid lances w/larger nozzles
31-Mar	118	615	1-5	4.9	9.2	4.0	7.5	294	19	18	69	1396	88	3	4.33	423	0.576	13	20	0.9	D	0.54	10.9	18.4	2	0.62	455	10.1	0	0	top/mid lances
31-Mar	119	615	1-5	4.9	9.2	4.0	7.5	481	30	39	148	2830	179	2,3	4.49	371	0.506	16	20	2.7	C	0.87	22.6	11.8	2	0.52	381	24.6	0	0	zone 2 & top/mid lances

Date 1999	Test No.	Load MW	Mills In Serv	APH del P: APH 1 in H_2O	APH 1 mm Hg	APH 2 in H_2O	APH 2 mm Hg	SNCR Injection System Operating Data: Urea Flow gph	Urea Flow lpm	Water Flow gpm	Water Flow lpm	Sol'n Flow gph	Sol'n Flow lpm	Injection Levels in Service	Gaseous Emissions Data: O_2 %	NO_x ppmc	NO_x lb/MMBtu	N_2O ppm	CO ppm	NH_3 ppm	NH_3 sample type	Calculated Data: Overall NSR	del NO %	del N_2O/ del NO, %	del CO ppm	CEM Data: NOx #/M	NOx ppmc	dNOx [%]	Economizer Profile Available: NO_x	NH_3	COMMENTS
31-Mar	120	615	1-5	4.9	9.2	4.0	7.5	481	30	40	151	2882	182	2,3	4.48	333	0.453	17	25	7.3	C	0.87	30.6	9.7	7	0.49	359	29.0	0	0	lower lance Pair
26-Mar	86	613	1-5	5.5	10.3	4.2	7.8	482	30	37	141	2716	171	2,3	5.25	367	0.500	18	25	5.6	C	0.85	26.0	11.5	8	nr	nr	nr	0	0	decreaseTop,incr bottom nsr
18-Mar	23	611	1-5	5.2	9.7	5.0	9.3	0	0	0	0	0	0	na	4.70	472	0.643	22	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	Baseline
18-Mar	24	611	1-5	5.2	9.7	5.0	9.3	420	26	9	34	965	61	3	4.43	402	0.547	28	25	1.6	P	0.79	13.1	10.8	5	nr	nr	nr	Y	P	Test 20 Repeat
18-Mar	25	611	1-5	5.2	9.7	5.0	9.3	417	26	13	49	1195	75	3	3.30	366	0.499	27	42.5	2.4	P	0.86	13.3	5.9	23	nr	nr	nr	Y	P	All MNLs in service
18-Mar	26	611	1-5	5.2	9.7	5.0	9.3	0	0	0	0	0	0	na	3.85	444	0.604	20	23.5	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	BL Repeat
18-Mar	27	611	1-5	5.2	9.7	5.0	9.3	420	26	13	49	1199	76	3	4.15	390	0.531	35	22	0.0	na	0.81	14.1	27.1	-2	nr	nr	nr	Y	N	Decrease Air P
18-Mar	28	611	1-5	5.2	9.7	5.0	9.3	168	11	5	20	484	31	3	4.25	441	0.600	29	21	0.0	na	0.32	3.7	60.6	-3	nr	nr	nr	Y	N	Top MNLs only
7-Apr	133	611	1-5	5.3	9.9	4.3	8.0	480	30	40	151	2872	181	2,3	4.73	349	0.476	19	17	4.3	C	0.92	23.2	15.1	0	0.51	374	27.1	Y	N	bal zone 2 inj, incr sidewall Pair
7-Apr	134	611	1-5	5.3	9.9	4.3	8.0	0	0	0	0	0	0	0	4.88	483	0.658	4	15	0.0	na	0.00	0.0	na	0	0.70	513	0.0	Y	N	Baseline
7-Apr	135	611	1-5	5.3	9.9	4.3	8.0	554	35	41	156	3020	191	2,3	4.88	343	0.467	19	17	3.9	C	1.00	29.0	12.0	2	0.51	374	28.2	Y	N	incr zone 3 nsr& H2O
7-Apr	136	611	1-5	5.3	9.9	4.3	8.0	0	0	0	0	0	0	0	4.93	490	0.668	5	15	0.0	na	0.00	-1.1		-2	0.71	521	-1.4	Y	N	Baseline
9-Apr	138	611	1-5	5.2	9.7	4.2	7.8	0	0	0	0	0	0	0	4.50	469	0.639	4	21.5	0.0	na	0.00	0.0	na	0	0.67	491	0.0	Y	N	Baseline
9-Apr	139	611	1-5	5.2	9.7	4.2	7.8	532	34	42	159	3053	193	2,3	4.53	322	0.439	22	28.5	0.0	C	0.99	31.5	13.6	7	0.46	337	31.3	Y	N	Zones 2&3, NH3 traverse
9-Apr	140	611	1-5	5.5	10.3	4.3	8.0	0	0	0	0	0	0	0	4.63	489	0.667	6	20	0.0	na	0.00	0.0	0.0	0	0.70	513	0.0	Y	N	Baseline
9-Apr	141	611	1-5	5.5	10.3	4.3	8.0	574	36	40	152	2983	188	2,3	4.50	340	0.463	12	25	0.0	na	1.03	29.9	4.6	5	0.46	337	34.3	Y	N	Bias lance injectors(north/south)
9-Apr	142	611	1-5	5.5	10.3	4.3	8.0	574	36	40	150	2951	186	2,3	4.58	312	0.425	27	27	0.0	na	1.09	32.1	14.6	10	0.43	315	35.8	Y	N	Bias lance injectors(north/south)
9-Apr	143	611	1-5	5.5	10.3	4.3	8.0	0	0	0	0	0	0	0	4.78	467	0.636	7	17	0.0	na	0.00	0.0	0.0	0	0.67	491	0.0	Y	N	Baseline
9-Apr	139A1	611	1-5	5.2	9.7	4.2	7.8	532	34	42	159	3053	193	2,3	4.55	335	0.457	21	25	0.0	T	0.99	28.8	14.1	4	0.48	352	28.4	Y	Y	Zones 2&3, NH3 traverse
9-Apr	139A4	611	1-5	5.5	10.3	4.3	8.0	589	37	41	156	3063	193	2,3	4.75	343	0.468	23	25	0.0	na	1.08	28.2	15.6	4	0.49	359	30.0	Y	N	Zones 2&3, NH3 traverse
17-Mar	10	610	1-5	4.9	9.2	4.8	9.0	0	0	0	0	0	0	na	4.58	485	0.661	18	18	0.1	S	0.00	0.0	na	0	nr	nr	nr	Y	S	Baseline
17-Mar	11	610	1-5	4.9	9.2	4.8	9.0	241	15	13	48	1005	63	3	4.43	443	0.603	22	20	0.0	na	0.44	7.7	0.0	2	nr	nr	nr	Y	N	Level 3 Design
17-Mar	12	610	1-5	4.9	9.2	4.8	9.0	241	15	16	61	1202	76	3	4.35	435	0.593	23	20	0.0	na	0.44	8.8	14.2	2	nr	nr	nr	Y	N	Vary Liquid
19-Mar	31	610	1-5	4.8	9.0	4.7	8.8	168	11	5	20	480	30	3	4.50	426	0.580	27	22	0.0	na	0.29	15.2	7.6	4	nr	nr	nr	Y	N	Zone 3 Middle MNLs
19-Mar	32	610	1-5	4.8	9.0	4.7	8.8	336	21	2	9	481	30	3	4.45	419	0.571	32	22	0.0	na	0.59	16.2	12.8	4	nr	nr	nr	Y	N	Increase NSR
19-Mar	33	610	1-5	4.8	9.0	4.7	8.8	234	15	1	4	300	19	3	4.28	441	0.601	27	22	0.0	na	0.41	10.6	10.5	4	nr	nr	nr	Y	N	Zone 3 Bot MNLs
19-Mar	34	610	1-5	4.8	9.0	4.7	8.8	0	0	0	0	0	0	na	4.40	480	0.654	22	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	BL Repeat
25-Mar	77	610	1-5	4.6	8.6	3.8	7.1	178	11	23	86	1545	97	2	4.38	424	0.577	10	22	2.1	na	0.32	12.9	7.5	3	nr	nr	nr	0	0	Zone 2 (all injs)
25-Mar	78	610	1-5	4.6	8.6	3.8	7.1	298	19	34	127	2314	146	2,3	4.39	416	0.567	11	22.5	2.2	na	0.54	14.6	8.1	4	0.60	440	17.8	0	0	Add Level 3 (C&F)

Optimization Data - Sorted by Load

Date	Test	Load	Mills	APH del P				SNCR INJECTION SYSTEM OPERATING DATA							GASEOUS EMISSIONS DATA							CALCULATED DATA				CEM Data			Economizer Profile Available		
				APH 1		APH 2		Urea Flow		Water Flow		Sol'n Flow		Injection Levels	O_2	NO_x	NO_x	N_2O	CO	NH_3	NH_3 sample	Overall	del NO	del N_2O/	del CO	NOx	NOx	dNOx			
1999	No.	MW	In Serv	in H_2O	mm Hg	in H_2O	mm Hg	gph	lpm	gpm	lpm	gph	lpm	in Service	%	ppmc	lb/MMBtu	ppm	ppm	ppm	type	NSR	%	del NO, %	ppm	#/M	ppmc	[%]	NO_x	NH_3	COMMENTS
25-Mar	79	610	1-5	4.6	8.6	3.8	7.1	371	23	40	151	2757	174	2,3	4.45	401	0.546	12	22.5	0.0	na	0.66	18.0	8.3	4	0.57	418	21.9	0	0	Add B&E MNLs
25-Mar	80	610	1-5	4.6	8.6	3.8	7.1	479	30	38	144	2759	174	2,3	4.33	379	0.516	15	24	3.7	P	0.86	21.8	10.3	5	0.54	396	26.0	0	0	Increase NSR - both levels
25-Mar	81	610	1-5	4.6	8.6	3.8	7.1	461	29	40	153	2891	182	2,3	4.45	383	0.522	16	24	4.7	na	0.83	21.7	11.2	5	0.56	411	23.3	0	0	Incr Lvl 2 NSR, decr Lvl 3 NSR
25-Mar	82	610	1-5	4.8	9.0	3.7	6.9	0	0	0	0	0	0	na	4.53	511	0.696	6	15	0.0	na	0.00	-3.9	-2.5	-4	0.73	535	0.0	0	0	Baseline repeat
22-Mar	53	609	1-5	4.9	9.2	4.8	9.0	0	0	0	0	0	0	na	4.40	472	0.643	4	19	0.0	na	0.00	0.0	na	0	0.69	506	0.0	0	0	Baseline
22-Mar	54	609	1-5	4.9	9.2	4.8	9.0	243	15	8	30	725	46	2	4.45	451	0.615	7	22	0.0	na	0.45	4.7	14.8	3	0.64	469	7.2	0	0	Level 2
17-Mar	16	608	1-5	4.9	9.2	4.8	9.0	240	15	16	61	1202	76	3	4.65	421	0.574	29	22	0.0	na	0.46	7.5	17.9	2	nr	nr	nr	Y	N	Decr Top MNL Air P
17-Mar	17	608	1-5	4.9	9.2	4.8	9.0	240	15	16	60	1192	75	3	4.80	425	0.579	29	22	0.0	na	0.46	7.7	18.6	2	nr	nr	nr	Y	N	Decr Top MNL Air P
17-Mar	18	608	1-5	4.9	9.2	4.8	9.0	240	15	16	60	1192	75	3	4.75	427	0.581	30	22	0.0	na	0.46	7.0	23.5	2	nr	nr	nr	Y	N	Decr Top MNL Air P
17-Mar	19	608	1-5	4.9	9.2	4.8	9.0	240	15	16	60	1192	75	3	4.75	424	0.577	28	22	0.0	na	0.46	7.6	0.0	2	nr	nr	nr	Y	N	Decrease Air P
17-Mar	20	608	1-5	4.9	9.2	4.8	9.0	240	15	9	33	764	48	3	4.55	421	0.574	27	22	0.0	na	0.47	6.7	14.3	2	nr	nr	nr	Y	N	A,D MNL OOS
17-Mar	21	608	1-5	4.9	9.2	4.8	9.0	420	26	9	33	944	60	3	4.73	420	0.573	30	22	0.0	na	0.81	8.2	20.8	2	nr	nr	nr	Y	N	Increase NSR
17-Mar	22	608	1-5	4.9	9.2	4.8	9.0	0	0	0	0	0	0	na	4.70	481	0.655	24	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	BL Repeat
19-Mar	30	608	1-5	4.8	9.0	4.7	8.8	0	0	0	0	0	0	na	4.53	473	0.644	22	18	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	Baseline
17-Mar	13	607	1-5	4.8	9.0	4.7	8.8	240	15	10	36	812	51	3	4.20	402	0.547	30	20	0.0	na	0.45	14.8	18.5	2	nr	nr	nr	Y	N	Vary Liquid
17-Mar	14	607	1-5	4.8	9.0	4.7	8.8	0	0	0	0	0	0	na	4.23	440	0.600	24	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	BL Repeat
17-Mar	15	607	1-5	4.8	9.0	4.7	8.8	240	15	16	60	1189	75	3	4.05	396	0.539	31	22	1.1	D	0.49	8.8	19.8	2	nr	nr	nr	Y	N	Vary Liquid
23-Mar	64	607	1-5	4.8	9.0	4.7	8.8	0	0	0	0	0	0	na	4.60	478	0.651	3	18	0.0	na	0.00	0.0	na	0	0.69	506	0.0	0	0	Baseline
23-Mar	65	607	1-5	4.8	9.0	4.7	8.8	299	19	36	134	2431	153	2,3	4.40	401	0.546	13	22	1.7	na	0.56	14.8	14.8	4	0.58	425	15.9	0	0	Levels 2 (11 inj) & 3 (4 inj)
23-Mar	66	607	1-5	4.8	9.0	4.7	8.8	299	19	32	119	2191	138	2,3	4.43	421	0.573	12	22	0.0	na	0.56	10.8	18.7	4	0.60	440	13.0	0	0	Reduce Level 3 injs to 2
23-Mar	67	607	1-5	4.8	9.0	4.7	8.8	301	19	33	124	2272	143	2,3	4.45	427	0.581	11	22	1.1	na	0.56	9.7	18.5	4	0.59	433	14.5	0	0	Decrease Air to Zone 3
23-Mar	68	607	1-5	4.8	9.0	4.7	8.8	0	0	0	0	0	0	na	4.30	496	0.676	4	18	0.0	D	0.00	-6.2	-1.6	0	0.72	528	-4.3	0	0	Baseline repeat
23-Mar	69	607	1-5	4.8	9.0	4.7	8.8	358	23	32	120	2255	142	2,3	4.20	431	0.587	12	22	2.3	na	0.68	7.0	30.5	4	0.60	440	16.7	0	0	Increase Level 3 NSR
27-Mar	94	606	1-5	5.4	10.1	4.8	9.0	481	30	37	139	2692	170	2,3	5.25	340	0.463	20	24.5	0.0	na	0.89	28.7	13.6	5	0.49	359	27.9	0	0	repeat test 80
27-Mar	95	606	1-5	5.4	10.1	4.8	9.0	479	30	34	129	2522	159	2,3	5.25	343	0.467	21	25.5	5.3	na	0.89	28.0	14.8	6	0.48	352	29.4	0	0	test 80 w/4 zone 2 inj oos
27-Mar	96	606	1-5	5.2	9.7	4.2	7.8	482	30	37	139	2685	169	2,3	5.11	348	0.475	17	25	4.7	P	0.88	27.8	10.1	6	0.47	345	30.9	0	0	repeat test 80
27-Mar	97	606	1-6	5.2	9.7	4.2	7.8	0	0	0	0	0	0	0	5.23	487	0.663	5	19.5	0.0	na	0.00	0.0	na	0	0.69	506	-1.5	0	0	Baseline
18-Mar	29	605	1-5	4.8	9.0	4.7	8.8	336	21	2	9	479	30	3	4.38	441	0.601	31	22	0.0	na	0.64	4.5	60.1	-2	nr	nr	nr	Y	N	Increase NSR
27-Mar	93	605	1-5	5.4	10.1	4.8	9.0	0	0	0	0	0	0	0	5.40	482	0.657	3	19.5	0.0	na	0.00	0.0	na	0	0.68	499	0.0	0	0	Baseline

Date 1999	Test No.	Load MW	Mills In Serv	APH del P: APH 1 in H_2O	APH del P: APH 1 mm Hg	APH del P: APH 2 in H_2O	APH del P: APH 2 mm Hg	SNCR Injection System Operating Data: Urea Flow gph	Urea Flow lpm	Water Flow gpm	Water Flow lpm	Sol'n Flow gph	Sol'n Flow lpm	Injection Levels in Service	Gaseous Emissions Data: O_2 %	NO_x ppmc	NO_x lb/MMBtu	N_2O ppm	CO ppm	NH_3 ppm	NH_3 sample type	Calculated Data: Overall NSR	del NO %	del N_2O/ del NO, %	del CO ppm	CEM Data: NOx #/M	NOx ppmc	dNOx [%]	Economizer Profile Available: NO_x	Economizer Profile Available: NH_3	COMMENTS
23-Mar	70	604	1-5	4.8	9.0	4.6	8.6	448	28	30	115	2270	143	2,3	4.15	419	0.571	12	22	2.9	na	0.86	9.2	22.5	4	0.59	433	18.1	0	0	Increase Level 2 NSR
23-Mar	71	604	1-5	4.8	9.0	4.6	8.6	0	0	0	0	0	0	na	4.15	486	0.662	4	18	0.0	na	0.00	-5.3	-1.8	0	0.72	528	0.0	0	0	Baseline repeat
20-Mar	41	603	1-5	5.1	9.5	4.7	8.8	0	0	0	0	0	0	na	5.03	473	0.645	4	18	0.0	na	0.00	0.0	na	0	0.69	506	0.0	Y	N	Baseline
20-Mar	42	603	1-5	5.1	9.5	4.7	8.8	168	11	29	109	1902	120	2	4.83	420	0.572	10	22	0.0	na	0.32	9.9	24.7	4	0.61	447	11.6	Y	N	Zone 2
20-Mar	43	603	1-5	5.1	9.5	4.7	8.8	330	21	26	100	1908	120	2	4.85	382	0.520	14	22	0.0	na	0.63	18.3	18.3	4	0.57	418	17.4	Y	N	Increase NSR
20-Mar	44	603	1-5	4.8	9.0	4.7	8.8	480	30	23	87	1854	117	2	4.83	370	0.504	17	25	8.0	C	0.91	20.7	19.3	7	0.54	396	21.7	Y	C	Increase NSR
20-Mar	45	603	1-5	4.8	9.0	4.7	8.8	330	21	16	59	1260	79	2	4.70	403	0.549	15	23	0.0	na	0.63	12.7	28.3	5	0.59	433	14.5	Y	N	Increase NSR
20-Mar	46	603	1-5	4.8	9.0	4.7	8.8	330	21	16	60	1278	81	2	4.73	415	0.565	13	22	0.0	na	0.63	10.4	30.5	4	0.59	433	14.5	Y	N	Remove sidewall injs
20-Mar	47	603	1-5	4.8	9.0	4.7	8.8	226	14	18	66	1276	81	2	4.60	420	0.572	8	22	0.0	na	0.44	8.4	21.8	4	0.61	447	11.6	Y	N	Remove front corner injs
20-Mar	48	602	1-5	4.9	9.2	4.7	8.8	0	0	0	0	0	0	na	4.73	484	0.659	8	18	0.0	na	0.00	0.0	na	0	0.72	528	-4.3	Y	N	Baseline Repeat
20-Mar	49	602	1-5	4.9	9.2	4.7	8.8	244	15	16	61	1207	76	3	4.58	444	0.605	nr	21	0.0	na	0.45	7.3	0.0	3	0.61	447	12.9	Y	N	Zone 3
20-Mar	50	600	1-5	4.8	9.0	4.6	8.6	242	15	8	29	705	44	3	4.65	470	0.641	11	22	0.0	na	0.45	2.3	37.2	4	0.6	440	13.0	Y	N	Remove top pair
20-Mar	51	600	1-5	4.8	9.0	4.6	8.6	601	38	23	86	1972	124	2,3	4.45	348	0.474	20	25	10.1	C	1.13	26.6	10.7	7	0.5	367	27.5	Y	N	Zones 2,3
20-Mar	52	600	1-5	4.8	9.0	4.6	8.6	0	0	0	0	0	0	na	4.63	478	0.651	4	18	0.0	na	0.00	0.5	0.0	0	0.69	506	0.0	Y	N	Baseline Repeat
22-Mar	55	600	1-5	4.9	9.2	4.8	9.0	0	0	0	0	0	0	na	4.38	479	0.653	4	18	0.0	na	0.00	0.0	na	0	0.67	491	0.0	0	0	Baseline
22-Mar	56	600	1-5	4.9	9.2	4.8	9.0	299	19	17	63	1292	82	2	4.38	425	0.579	10	25	2.0	P	0.56	11.3	13.6	7	0.58	425	13.4	0	0	Level 2
22-Mar	57	600	1-5	4.9	9.2	4.8	9.0	152	10	19	72	1291	81	2	4.35	449	0.611	8	22	0.0	na	0.28	6.2	17.5	4	0.65	477	3.0	0	0	Decrease NSR
22-Mar	58	600	1-5	4.9	9.2	4.8	9.0	468	30	13	51	1269	80	2	4.25	416	0.567	11	22	3.9	C	0.88	12.3	13.9	4	0.61	447	9.0	0	0	Increase NSR
7-Apr	128	600	1-5	5.4	10.1	4.4	8.2	0	0	0	0	0	0	0	5.40	479	0.653	4	12	0.0	na	0.00	0.0	na	-4	0.70	513	0.0	Y	N	Baseline
7-Apr	129	600	1-5	5.4	10.1	4.4	8.2	90	6	8	29	551	35	2	5.28	448	0.610	7	12	0.0	na	0.17	5.6	10.9	-4	0.65	477	7.1	Y	N	Level 2 sidewalls only
7-Apr	130	600	1-5	5.4	10.1	4.4	8.2	180	11	26	97	1725	109	2	5.18	424	0.578	10	12	2.4	C	0.34	10.0	13.2	-4	0.61	447	12.9	Y	N	Level 2 all,bias to sidewall
7-Apr	131	600	1-5	5.4	10.1	4.4	8.2	270	17	25	94	1755	111	2	5.03	409	0.557	12	13.5	4.0	C	0.52	12.3	14.7	0	0.60	440	14.3	Y	N	Level 2 all,bias to sidewall
7-Apr	132	600	1-5	5.4	10.1	4.4	8.2	449	28	41	155	2904	183	2,3	4.83	356	0.485	17	17	4.2	C	0.87	22.3	14.0	0	0.51	374	27.1	Y	N	incr nsr
22-Mar	59	597	1-5	4.9	9.2	4.7	8.8	299	19	20	75	1481	93	2	4.30	426	0.580	13	22	3.9	C	0.56	10.6	19.2	4	0.57	418	14.9	0	0	Decrease NSR, increase water
22-Mar	60	597	1-5	4.9	9.2	4.7	8.8	0	0	0	0	0	0	na	4.35	481	0.655	4	20	0.0	na	0.00	0.0	na	0	0.69	506	-3.0	0	0	Baseline
22-Mar	61	597	1-5	4.9	9.2	4.7	8.8	298	19	28	104	1948	123	2,3	4.35	384	0.523	16	22	0.0	na	0.55	20.2	12.8	2	0.54	396	21.7	0	0	Levels 2 & 3
22-Mar	62	597	1-5	4.9	9.2	4.7	8.8	450	28	25	94	1938	122	2,3	4.43	372	0.507	20	25	3.9	P	0.83	23.1	15.6	5	0.52	381	24.6	0	0	Increase NSR
22-Mar	63	597	1-5	4.9	9.2	4.7	8.8	0	0	0	0	0	0	na	4.50	488	0.665	5	18	0.0	na	0.00	0.0	na	0	0.69	506	0.0	0	0	Baseline repeat
15-Mar	3b	596	1-5	nr	nr	nr	nr	0	0	0	0	0	0	na	4.63	500	0.682	0	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	N	N	BL Repeat
15-Mar	1	595	1-5	nr	nr	nr	nr	0	0	0	0	0	0	na	4.55	503	0.686	0	20	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	Baseline

Optimization Data - Sorted by Load

Date 1999	Test No.	Load MW	Mills In Serv	APH del P: APH 1 in H_2O	APH del P: APH 1 mm Hg	APH del P: APH 2 in H_2O	APH del P: APH 2 mm Hg	SNCR Injection System Operating Data: Urea Flow gph	Urea Flow lpm	Water Flow gpm	Water Flow lpm	Sol'n Flow gph	Sol'n Flow lpm	Injection Levels in Service	Gaseous Emissions Data: O_2 %	NO_x ppmc	NO_x lb/MMBtu	N_2O ppm	CO ppm	NH_3 ppm	NH_3 sample type	Calculated Data: Overall NSR	del NO %	del N_2O/ del NO, %	del CO ppm	CEM Data: NOx #/M	NOx ppmc	dNOx [%]	Economizer Profile Available: NO_x	NH_3	COMMENTS
15-Mar	2	595	1-5	nr	nr	nr	nr	480	30	nr	nr	na	na	1	4.53	497	0.677	0	20	0.0	na	0.86	1.1	0.0	0	nr	nr	nr	Y	N	Lvl 1 Check
15-Mar	3	595	1-5	nr	nr	nr	nr	510	32	nr	nr	na	na	1,2	4.50	436	0.595	0	20	0.0	na	0.91	13.0	0.0	0	nr	nr	nr	Y	N	Lvls 1,2
25-Mar	76	590	1,3,4,9	nr	nr	nr	nr	0	0	0	0	0	0	na	4.48	490	0.668	5	19	0.0	na	0.00	0.0	na	0	nr	nr	nr	0	0	Baseline (5 mills)
25-Mar	75	589	1,3,4,8	nr	nr	nr	nr	0	0	0	0	0	0	na	4.68	438	0.597	4	18.5	0.0	na	0.00	-0.5	-28.6	1	nr	nr	nr	0	0	Baseline Repeat
25-Mar	74	588	1,3,4,7	nr	nr	nr	nr	148	9	7	27	572	36	3	4.77	419	0.571	5	18	0.0	na	0.31	4.6	14.2	1	nr	nr	nr	0	0	Increase liquid flow
25-Mar	73	587	1,3,4,6	nr	nr	nr	nr	150	9	6	23	515	33	3	4.80	417	0.568	5	18.5	0.2	na	0.31	5.3	8.6	1	nr	nr	nr	0	0	Level 3 (C&F)
25-Mar	72	586	1,3,4,5	nr	nr	nr	nr	0	0	0	0	0	0	na	4.88	443	0.604	3	17.5	0.0	na	0.00	0.0	na	0	0.64	469	0.0	0	0	Baseline (4 mills- #2 OOS)
21-Apr	175	575	1-5	4.8	9.0	3.8	7.1	480	30	33	125	2465	156	0	4.48	337	0.459	13	23	0.0	P(v+h)	0.99	25.0	10.7	6	0.49	359	29.0	Y	0	zones 2&3, small bias
21-Apr	176	575	1-5	4.8	9.0	3.8	7.1	0	0	0	0	0	0	0	4.53	431	0.587	4	16.5	0.0	0	0.00	4.3	0.0	0	0.64	469	7.2	Y	0	Baseline
21-Apr	168	573	1-5	4.9	9.2	3.8	7.1	0	0	0	0	0	0	0	4.95	466	0.634	2	17	0.0	0	0.00	0.0	na	0	0.69	506	0.0	Y	0	Baseline
21-Apr	169	573	1-5	4.9	9.2	3.8	7.1	241	15	16	59	1180	74	2	4.88	416	0.567	7	17	0.0	0	0.48	10.2	12.4	0	0.63	462	8.7	Y	0	zone 2
21-Apr	170	573	1-5	4.9	9.2	3.8	7.1	239	15	19	71	1358	86	2	4.78	408	0.556	9	17	0.0	0	0.48	11.2	14.9	0	0.62	455	10.1	Y	0	zone 2, higher H2O
21-Apr	171	573	1-5	4.9	9.2	3.8	7.1	239	15	22	82	1535	97	2	4.70	408	0.555	9	17	5.0	D	0.49	10.8	17.0	0	0.60	440	13.0	Y	0	zone 2 Higher H2O
21-Apr	172	573	1-5	4.9	9.2	3.8	7.1	478	30	38	143	2742	173	2,3	4.53	327	0.445	17	22	7.8	P(mid)	0.99	27.5	13.7	5	0.49	359	29.0	Y	0	zones 2&3, small bias
21-Apr	173	573	1-5	4.9	9.2	3.8	7.1	478	30	37	138	2670	168	0	4.53	329	0.448	14	23	6.7	P(mid)	0.99	27.0	10.9	6	0.49	359	29.0	Y	0	zones 2&3, small bias
21-Apr	174	573	1-5	4.9	9.2	3.8	7.1	481	30	35	131	2555	161	0	4.53	336	0.458	14	23	0.0	0	0.99	25.4	11.7	6	0.50	367	27.5	Y	0	zones 2&3, bias from wall (25%)
19-Mar	35	562	2-5	4.2	7.8	4.1	7.7	0	0	0	0	0	0	na	4.48	458	0.623	23	18	0.0	na	0.00	0.0	na	0	nr	nr	nr	Y	N	Baseline - 550 MW
19-Mar	36	562	2-5	4.2	7.8	4.1	7.7	210	13	13	48	979	62	3	4.55	429	0.585	28	21	0.0	na	0.43	6.7	17.6	3	nr	nr	nr	Y	N	Zone 3
19-Mar	37	562	2-5	4.2	7.8	4.1	7.7	366	23	11	41	1008	64	3	4.60	412	0.561	32	22	3.5	na	0.75	10.9	19.0	4	nr	nr	nr	Y	N	Increase NSR
19-Mar	38	562	2-5	4.2	7.8	4.1	7.7	367	23	25	93	1838	116	2	4.70	392	0.534	32	22	0.0	na	0.75	15.8	13.7	4	nr	nr	nr	Y	N	Zone 2
19-Mar	39	562	2-5	4.2	7.8	4.1	7.7	367	23	40	150	2740	173	1,2	4.70	378	0.515	29	22	0.0	na	0.75	18.8	7.8	4	nr	nr	nr	Y	N	Zone 2 + Z1 rear wall
19-Mar	40	562	2-5	4.2	7.8	4.1	7.7	410	26	40	151	2799	177	2,3	4.68	353	0.480	37	25	0.0	na	0.84	24.1	14.2	7	nr	nr	nr	Y	N	Zones 2,3
6-Apr	122	531	1-5	4.2	7.8	3.4	6.4	0	0	0	0	0	0	0	4.85	446	0.608	3	17.5	0.0	na	0.00	0.0	na	0	0.62	455	0.0	Y	N	Baseline
6-Apr	123	531	1-5	4.2	7.8	3.4	6.4	229	14	26	99	1799	113	2	4.75	340	0.463	13	17	9.1	C	0.52	23.3	11.2	-1	0.49	359	21.0	Y	N	Level 2
6-Apr	124	531	1-5	4.2	7.8	3.4	6.4	228	14	27	102	1848	117	2	4.70	357	0.487	11	17.5	5.8	C	0.52	18.9	10.6	0	0.52	381	16.1	Y	N	Level 2, Increase liquid & air P
6-Apr	125	529	1-5	4.3	8.0	3.3	6.2	0	0	0	0	0	0	0	4.63	439	0.598	2	16	0.0	na	0.00	0.0	na	0	0.61	447	0.0	Y	N	Baseline repeat
6-Apr	126	529	1-5	4.3	8.0	3.3	6.2	468	30	43	164	3068	194	2,3	4.68	315	0.430	20	16	8.1	C	1.07	28.4	15.9	0	0.44	323	29.0	Y	N	Levels 2,3
6-Apr	127	528	1-5	4.2	7.8	3.3	6.2	0	0	0	0	0	0	0	4.80	459	0.625	3	16	0.0	na	0.00	0.0	na	0	0.62	455	0.0	Y	N	Baseline repeat

Date 1999	Test No.	Load MW	Mills In Serv	APH del P: APH 1 in H_2O	APH 1 mm Hg	APH 2 in H_2O	APH 2 mm Hg	SNCR INJECTION SYSTEM OPERATING DATA: Urea Flow gph	Urea Flow lpm	Water Flow gpm	Water Flow lpm	Sol'n Flow gph	Sol'n Flow lpm	Injection Levels in Service	GASEOUS EMISSIONS DATA: O_2 %	NO_x ppmc	NO_x lb/MMBtu	N_2O ppm	CO ppm	NH_3 ppm	NH_3 sample type	CALCULATED DATA: Overall NSR	del NO %	del N_2O/ del NO, %	del CO ppm	CEM Data: NOx #/M	NOx ppmc	dNOx [%]	Economizer Profile Available: NO_x	NH_3	COMMENTS
29-Mar	110	471	1-5	3.5	6.5	2.7	5.0	300	19	30	112	2081	131	2,3	5.48	295	0.401	18	24	6.7	C	0.83	27.7	13.4	6	nr	nr	nr	Y	0	incr nsr to zone 2, decr nsr zone 3
29-Mar	111	471	1-5	3.5	6.5	2.7	5.0	0	0	0	0	0	0	2,3	5.63	424	0.577	3	17.5	0.0	0	0.00	-2.6	16.2	-1	0.58	425	0.0	Y	0	
29-Mar	103	470	1-5	3.5	6.5	2.8	5.2	0	0	0	0	0	0	0	5.75	415	0.565	2	19	0.0	0	0.00	0.0	na	0	0.58	425	0.0	Y	0	Baseline
29-Mar	104	470	1-5	3.5	6.5	2.8	5.2	77	5	18	69	1165	73	2	5.70	371	0.505	7	20.5	0.0	0	0.21	10.2	13.3	2	0.52	381	10.3	Y	0	Level 2
29-Mar	105	470	1-5	3.5	6.5	2.8	5.2	154	10	17	64	1167	74	2	5.68	345	0.470	11	21.5	0.0	0	0.43	16.3	14.9	3	0.48	352	17.2	Y	0	Level 2, increase nsr
29-Mar	106	470	1-5	3.5	6.5	2.8	5.2	155	10	20	76	1360	86	2	5.69	340	0.463	9	22	5.3	C	0.43	17.6	11.7	3	0.48	352	17.2	Y	0	increase H2O
29-Mar	107	470	1-5	3.5	6.5	2.8	5.2	234	15	16	60	1188	75	2	5.60	321	0.437	13	23	7.9	C	0.65	21.7	13.8	4	0.46	337	20.7	Y	0	decrease H2O, incr nsr
29-Mar	108	470	1-5	3.5	6.5	2.8	5.2	0	0	0	0	0	0	0	5.65	414	0.564	5	18.5	0.0	0	0.00	0.0	na	0	0.59	433	-1.7	Y	0	Baseline
29-Mar	109	470	1-5	3.5	6.5	2.8	5.2	299	19	30	113	2092	132	2,3	5.48	284	0.387	22	25	6.4	P	0.83	30.2	16.0	7	0.39	286	33.9	Y	P	0
22-Apr	181	457	1,2,4,5	4.1	7.7	3.3	6.2	340	21	23	85	1691	107	1,2	6.88	342	0.467	9	19	0.0	0	0.88	24.3	8.3	4	0.50	367	25.4	Y	0	Zone1 (rear)+ zone 3, higher H2O
22-Apr	182	457	1,2,4,5	4.1	7.7	3.3	6.2	341	22	26	97	1885	119	1,2	6.80	337	0.460	10	19	0.0	0	0.89	25.0	9.0	4	0.49	356	27.6	Y	0	Vary liquid flow
22-Apr	183	457	1,2,4,5	4.1	7.7	3.3	6.2	340	21	40	151	2731	172	1,2	6.88	322	0.439	16	22	4.6	C	0.88	28.8	13.7	7	0.45	330	32.8	Y	0	Add zone 3
22-Apr	184	457	1,2,4,5	4.1	7.7	3.3	6.2	329	21	40	152	2739	173	1,2,3,	6.75	307	0.418	21	23	6.5	C	0.86	31.5	16.6	8	0.43	315	35.8	Y	0	0
22-Apr	185	457	1,2,4,5	4.1	7.7	3.3	6.2	0	0	0	0	0	0	0	6.79	463	0.630	1	15	0.0	C	0.00	0.0	0.0	0	0.66	484	1.5	Y	0	Baseline
22-Apr	186	457	1,2,4,5	4.1	7.7	3.3	6.2	322	20	36	136	2474	156	1,2,3,	6.75	288	0.392	21	22.5	6.9	C	0.82	37.6	14.6	8	0.40	293	39.4	Y	0	0
22-Apr	187	457	1,2,4,5	4.1	7.7	3.3	6.2	289	18	36	138	2477	156	1,2,3,	6.70	300	0.409	20	22.5	6.0	C	0.74	34.6	14.8	8	0.43	315	34.8	Y	0	0
22-Apr	188	457	1,2,4,5	4.1	7.7	3.3	6.2	0	0	0	0	0	0	0	6.77	462	0.629	2	17	0.0	0	0.00	0.0	0.0	2	0.65	477	3.0	Y	0	Baseline
27-Mar	98	454	1.2.4,5	3.7	6.9	2.8	5.2	0	0	0	0	0	0	3	6.80	430	0.586	5	16	0.0	na	0.00	1.6	23.7	-1	0.57	418	0.0	0	0	Baseline 450 MW
27-Mar	99	454	1.2.4,5	3.7	6.9	2.8	5.2	96	6	5	19	392	25	3	6.30	374	0.510	8	20	0.0	na	0.27	10.8	12.8	4	0.51	374	10.5	0	0	Mid lance, NSR=.2
27-Mar	100	454	1.2.4,5	3.7	6.9	2.8	5.2	144	9	7	27	566	36	3	6.35	363	0.495	11	20	0.0	na	0.40	13.8	16.9	4	0.49	359	14.0	0	0	Mid/Top Lance, NSR=.3
27-Mar	101	454	1.2.4,5	3.7	6.9	2.8	5.2	286	18	14	51	1100	69	3	6.28	306	0.417	23	23.5	10.6	C	0.80	27.0	20.8	7	0.42	308	26.3	0	0	All Lances. NSR=0.8
27-Mar	102	454	1.2.4,5	3.7	6.9	2.8	5.2	0	0	0	0	0	0	0	6.40	423	0.576	3	16.5	0.0	na	0.00	0.0	na	0	0.58	425	0.0	0	0	Baseline
22-Apr	177	453	1,2,4,5	4.2	7.8	3.2	6.0	0	0	0	0	0	0	na	7.03	458	0.623	2	15	0.0	0	0.00	0.0	0.0	0	0.67	491	0.0	Y	0	Baseline
22-Apr	178	453	1,2,4,5	4.2	7.8	3.2	6.0	167	11	9	35	727	46	1	7.03	387	0.527	6	17	0.0	0	0.43	15.5	6.4	2	0.57	418	14.9	N	0	Level 1, rear wall
22-Apr	179	453	1,2,4,5	4.2	7.8	3.2	6.0	304	19	14	52	1132	71	1	6.88	376	0.513	6	18	0.0	0	0.79	16.8	6.7	3	0.55	403	17.9	Y	0	Level 1, rear wall + 5 front wall
22-Apr	180	453	1,2,4,5	4.2	7.8	3.2	6.0	341	22	19	73	1490	94	1,2	6.90	355	0.483	8	18	0.0	0	0.89	21.8	7.2	3	0.51	374	23.9	Y	0	Zone1 (rear)+ zone 2
23-Apr	189	450	1-5	4.3	8.0	3.2	6.0	0	0	0	0	0	0	0	6.95	426	0.580	3	15	0.0	0	0.00	0.0	0.0	0	0.61	447	0.0	Y	0	Baseline
23-Apr	190	450	1-5	4.3	8.0	3.2	6.0	154	10	9	36	719	45	1	6.60	346	0.472	2	16.5	0.5	0	0.44	16.2	-2.0	2	0.50	367	18.0	Y	0	Zone 1
23-Apr	191	450	1-5	4.3	8.0	3.2	6.0	229	14	24	92	1685	106	1,2	6.55	315	0.429	10	18	1.2	0	0.66	23.6	8.9	3	0.47	345	23.0	Y	0	Zones 1&2
23-Apr	192	450	1-5	4.3	8.0	3.2	6.0	322	20	36	136	2484	157	1,2,3	6.45	288	0.393	14	20	2.7	0	0.93	29.3	10.8	5	0.40	293	34.4	Y	0	Zones 1,2,3,

Optimization Data - Sorted by Load

Date 1999	Test No.	Load MW	Mills In Serv	APH del P: APH 1 in H_2O	APH del P: APH 1 mm Hg	APH del P: APH 2 in H_2O	APH del P: APH 2 mm Hg	SNCR Injection System Operating Data: Urea Flow gph	Urea Flow lpm	Water Flow gpm	Water Flow lpm	Sol'n Flow gph	Sol'n Flow lpm	Injection Levels in Service	Gaseous Emissions Data: O_2 %	NO_x ppmc	NO_x lb/MMBtu	N_2O ppm	CO ppm	NH_3 ppm	NH_3 sample type	Calculated Data: Overall NSR	del NO %	del N_2O/ del NO, %	del CO ppm	CEM Data: NOx #/M	NOx ppmc	dNOx [%]	Economizer Profile Available: NO_x	NH_3	COMMENTS
23-Apr	193	450	1-5	4.3	8.0	3.2	6.0	270	17	36	138	2458	155	1,2,3	6.45	283	0.385	17	20	3.4	P(1-6,7-12)	0.79	30.7	13.3	5	0.40	293	34.4	Y	0	Zones 1,2,3,
23-Apr	194	450	1-5	4.3	8.0	3.2	6.0	0	0	0	0	0	0	0	6.55	417	0.568	1	20	0.0	0	0.00	-1.3	0.0	5	0.60	440	1.6	Y	0	Baseline
27-Apr	218	408	1-3,5	4.5	8.4	3.7	6.9	0	0	0	0	0	0	0	7.13	379	0.516	1	20	0.0	0	0.00	0.0	na	0	0.54	396	0.0	Y	0	Baseline
27-Apr	219	408	1-3,5	4.5	8.4	3.7	6.9	149	9	10	36	725	46	1	6.98	313	0.427	7	21	0.0	0	0.52	16.1	11.7	1	0.45	330	16.7	Y	0	Baseline
27-Apr	220	408	1-3,5	4.5	8.4	3.7	6.9	151	10	24	90	1574	99	1	6.90	322	0.439	7	21.5	0.0	0	0.53	13.1	14.4	2	0.46	337	14.8	Y	0	Zones 1&2
27-Apr	221	408	1-3,5	4.5	8.4	3.7	6.9	252	16	37	139	2461	155	1,2	6.95	281	0.383	10	22.5	1.9	0	0.88	24.7	12.5	3	0.41	301	24.1	0	0	Zones 1&2 incr nsr
27-Apr	222	408	1-3,5	4.5	8.4	3.7	6.9	276	17	38	142	2533	160	1,2	6.79	272	0.371	16	23.5	3.1	0	0.98	25.8	20.1	4	0.39	286	27.8	0	0	Zones 1&2 incr nsr Z2,decr Z1
27-Apr	223	408	1-3,5	4.5	8.4	3.7	6.9	280	18	49	184	3190	201	1,2,3	6.85	239	0.325	21	26	6.2	0	0.99	35.4	19.0	6	0.34	249	37.0	0	0	Zones 1,2&3
27-Apr	224	408	1-3,5	4.5	8.4	3.7	6.9	253	16	49	185	3178	200	1,2,3	6.43	214	0.291	22	26.5	6.5	0	0.93	39.6	18.4	7	0.32	235	40.7	0	0	Zones 1,2&3
27-Apr	225	408	1-3,5	4.5	8.4	3.7	6.9	253	16	35	132	2342	148	1,2,3	6.53	221	0.301	20	26	0.0	D	0.92	38.3	17.2	6	0.33	242	38.9	0	0	Zones 1,2&3, decr H2O
27-Apr	226	408	1-3,5	4.5	8.4	3.7	6.9	0	0	0	0	0	0	0	6.65	371	0.505	2	18.5	0.0	D	0.00	-2.4	-3.1	-2	nr	nr	0.0	0	0	Baseline
26-Mar	87	370	2-5	2.8	5.2	2.2	4.1	0	0	0	0	0	0	na	7.03	393	0.536	4	21	0.0	na	0.00	0.0	na	0	0.55	403	0.0	0	0	Baseline 370 MW
26-Mar	88	370	2-5	2.8	5.2	2.2	4.1	117	7	11	41	771	49	2	7.48	343	0.467	7	22	0.0	na	0.41	16.2	5.3	1	0.49	359	12.5	0	0	Zone 2 (13inj)
26-Mar	89	370	2-5	2.8	5.2	2.2	4.1	117	7	18	67	1185	75	2	7.53	329	0.448	9	23	3.4	C	0.41	20.0	7.6	2	0.47	345	16.1	0	0	Zone 2 (13inj)
10-Apr	144	353	1,3-5	3.1	5.8	2.1	3.9	0	0	0	0	0	0	0	7.64	383	0.522	4	17.5	0.0	0	0.00	0.0	0.0	0	0.58	425	0.0	0	N	Baseline
10-Apr	145	353	1,3-5	3.1	5.8	2.1	3.9	118	7	53	199	3275	207	1	7.50	336	0.457	6	19	0.0	0	0.47	11.2	7.3	2	0.49	359	15.5	0	N	zone 1 all
10-Apr	146	353	1,3-5	3.1	5.8	2.1	3.9	240	15	51	192	3280	207	1	7.48	302	0.411	8	20.5	0.0	0	0.96	20.0	8.5	3	0.43	315	25.9	0	N	zone 1 all, incr nsr
10-Apr	147	353	1,3-5	3.1	5.8	2.1	3.9	61	4	13	50	847	53	1	7.58	360	0.491	4	18.5	0.0	0	0.24	5.4	3.5	1	0.52	381	10.3	0	N	zone 1 rear
10-Apr	148	353	1,3-5	3.1	5.8	2.1	3.9	95	6	17	65	1128	71	1	7.58	370	0.504	4	18.5	0.0	0	0.38	2.9	7.1	1	0.52	381	11.9	0	N	zone1 sides
10-Apr	149	353	1,3-5	3.1	5.8	2.1	3.9	0	0	0	0	0	0	0	7.75	405	0.551	2	17	0.0	0	0.00	0.0	0.0	-1	0.59	433	0.0	0	N	Baseline
10-Apr	150	353	1,3-5	3.1	5.8	2.1	3.9	97	6	19	71	1222	77	1	7.60	364	0.497	4	18	0.0	0	0.37	8.7	5.7	-4	0.54	396	8.5	0	N	zone 1 front
10-Apr	151	353	1,3-5	3.1	5.8	2.1	3.9	152	10	46	175	2924	184	1,2	7.53	212	0.289	14	17.5	0.0	0	0.58	46.5	8.1	-4	0.37	271	37.3	0	N	zones1 &2
10-Apr	152	353	1,3-5	3.1	5.8	2.1	3.9	na	na	na	na	na	ma	na	nr	nr	na	nr	nr	nr	na	na	na	na	nr	0.00	0	0.0	nr	nr	test aborted, broken hose
10-Apr	153	353	1,3-5	3.1	5.8	2.1	3.9	54	3	6	24	442	28	2	7.65	370	0.505	5	17.5	0.0	0	0.20	7.6	10.7	-4	0.53	389	10.2	0	N	zone 2 sides
10-Apr	154	353	1,3-5	3.1	5.8	2.1	3.9	101	6	16	59	1036	65	2	7.50	337	0.459	10	19	0.0	0	0.39	14.8	15.1	-3	0.50	367	13.8	0	N	zone 2 front
10-Apr	155	353	1,3-5	3.1	5.8	2.1	3.9	0	0	0	0	0	0	0	7.53	404	0.550	4	17	0.0	0	0.00	-1.8	-16.9	-5	0.58	425	0.0	0	N	Baseline
12-Apr	156	343	1,2,4,5	3.2	6.0	2.2	4.1	0	0	0	0	0	0	0	8.00	401	0.547	3	18	0.0	0	0.00	0.0	na	0	0.54	396	0.0	Y	0	Baseline
12-Apr	157	343	1,2,4,5	3.2	6.0	2.2	4.1	150	9	23	86	1506	95	2	8.05	297	0.405	14	22	8.1	C	0.58	26.3	15.6	4	0.42	308	22.2	Y	0	Level 2
12-Apr	158	343	1,2,4,5	3.2	6.0	2.2	4.1	224	14	21	81	1508	95	2	8.08	266	0.363	17	24.5	18.2	C	0.86	34.1	14.5	7	0.43	315	20.4	Y	0	Level 2,incr nsr
12-Apr	159	343	1,2,4,5	3.2	6.0	2.2	4.1	222	14	23	87	1596	101	2	8.23	262	0.356	17	25	18.3	C	0.84	36.1	14.1	7	0.42	308	22.2	Y	0	Level 2,incr nsr,incr Pair

Date 1999	Test No.	Load MW	Mills In Serv	APH del P: APH 1 in H_2O	APH del P: APH 1 mm Hg	APH del P: APH 2 in H_2O	APH del P: APH 2 mm Hg	SNCR Injection System Operating Data: Urea Flow gph	Urea Flow lpm	Water Flow gpm	Water Flow lpm	Sol'n Flow gph	Sol'n Flow lpm	Injection Levels in Service	Gaseous Emissions Data: O_2 %	NO_x ppmc	NO_x lb/MMBtu	N_2O ppm	CO ppm	NH_3 ppm	NH_3 sample type	Calculated Data: Overall NSR	del NO %	del N_2O/ del NO, %	del CO ppm	CEM Data: NOx #/M	NOx ppmc	dNOx [%]	Economizer Profile Available: NO_x	NH_3	COMMENTS
12-Apr	160	343	1,2,4,5	3.2	6.0	2.2	4.1	300	19	21	78	1530	97	2	8.30	236	0.322	21	27.5	31.2	C	1.13	42.7	14.9	10	0.39	286	35.5	Y	0	Level 2,inr nsr, orig Pair
12-Apr	161	343	1,2,4,5	3.2	6.0	2.2	4.1	0	0	0	0	0	0	0	8.30	416	0.566	3	17	0.0	0	0.00	0.0	na	-1	0.61	444	0.0	Y	0	Baseline
12-Apr	162	343	1,2,4,5	3.2	6.0	2.2	4.1	150	9	7	26	558	35	2	8.10	345	0.470	5	20	1.3	C	0.58	14.8	5.9	2	0.46	337	24.0	Y	P	Level 2 test 157 w lower H2O
26-Mar	90	340	2-5	2.8	5.2	2.1	3.9	0	0	0	0	0	0	na	7.60	411	0.560	5	14	0.0	na	0.00	0.8	38.8	-7	0.56	411	0.0	0	0	Baseline
26-Mar	91	340	2-5	2.8	5.2	2.1	3.9	108	7	32	122	2034	128	1	7.53	370	0.504	4	17.5	0.0	na	0.41	10.1	1.2	-4	0.51	374	8.9	0	0	Zone 1 (23 inj)
26-Mar	92	340	2-5	2.8	5.2	2.1	3.9	109	7	49	187	3067	194	1	7.58	352	0.480	6	17	0.0	na	0.41	14.7	3.7	-4	0.49	359	12.5	0	0	Increase water flow
12-Apr	163	340	1,2,4,6	3.3	6.2	2.3	4.3	109	7	12	44	799	50	3	8.10	325	0.443	18	27	9.4	C	0.42	19.6	26.4	9	0.46	337	24.0	Y	0	Level 3 top /mid lances
12-Apr	164	340	1,2,4,7	3.3	6.2	2.3	4.3	109	7	5	18	395	25	3	8.08	349	0.476	15	23.5	15.1	C	0.42	13.5	30.6	6	0.49	359	19.0	Y	0	#REF!
12-Apr	165	340	1,2,4,8	3.3	6.2	2.3	4.3	120	8	53	199	3273	206	1	7.93	326	0.444	8	20.5	2.2	C	0.45	22.5	7.4	2	0.46	337	23.3	Y	0	Level 3 mid lances
12-Apr	166	340	1,2,4,9	3.3	6.2	2.3	4.3	0	0	0	0	0	0	0	7.68	411	0.560	3	18.5	0.0	0	0.00	0.0	na	0	0.60	440	0.0	Y	0	Baseline
24-Apr	199	340	1,2,4,5	3.2	6.0	2.3	4.3	0	0	0	0	0	0	0	8.00	400	0.545	3	15	0.0	0	0.00	0.0	0.0	0	0.58	425	0.0	Y	0	Baseline 3mill oos,#4mill biased down
24-Apr	200	340	1,2,4,5	3.2	6.0	2.3	4.3	148	9	23	87	1525	96	1	8.10	307	0.418	10	20	0.0	0	0.57	24.0	9.4	5	0.43	315	25.9	Y	0	Zone 1
24-Apr	201	340	1,2,4,5	3.2	6.0	2.3	4.3	203	13	34	129	2245	142	1,2	8.05	257	0.351	15	20	2.0	0	0.79	35.9	11.1	5	0.38	279	34.5	Y	0	Zones 1&2
24-Apr	202	340	1,2,4,5	3.2	6.0	2.3	4.3	207	13	34	127	2225	140	1,2	8.20	277	0.377	13	20	2.4	0	0.80	32.0	10.3	5	0.39	286	32.8	Y	0	Zones 1&2, nsr1-,nsr2+
24-Apr	203	340	1,2,4,5	3.2	6.0	2.3	4.3	209	13	44	167	2849	180	1,2,3	8.20	263	0.358	16	20	7.6	0	0.81	35.5	12.2	5	0.38	279	34.5	Y	0	Zones 1,2,3,
24-Apr	204	340	1,2,4,5	3.2	6.0	2.3	4.3	0	0	0	0	0	0	0	8.40	424	0.578	3	15	0.0	0	0.00	-2.4	5.9	0	0.62	455	0.0	Y	0	Baseline
24-Apr	205	340	1,2,4,5	3.2	6.0	2.3	4.3	152	10	32	120	2051	129	1,3	8.30	306	0.418	14	20	0.0	0	0.58	25.4	14.4	5	0.44	323	29.0	Y	0	Zones 1&3
24-Apr	206	340	1,2,4,5	3.2	6.0	2.3	4.3	216	14	33	127	2223	140	1,2	8.25	275	0.375	12	20	0.0	0	0.83	32.7	9.0	5	0.41	301	33.9	Y	0	Zones 1&2
24-Apr	207	340	1,2,4,5	3.2	6.0	2.3	4.3	256	16	33	124	2225	140	1,2	8.35	260	0.354	15	20	0.0	0	0.98	36.9	10.8	5	0.38	279	38.7	Y	0	Zones 1&2,incr nsr1
24-Apr	208	340	1,2,4,5	3.2	6.0	2.3	4.3	312	20	32	122	2251	142	1,2	8.30	245	0.333	17	20	0.0	0	1.19	40.4	12.0	5	0.36	264	41.9	Y	0	Zones 1&2,incr nsr1, incr nsr2
24-Apr	209	340	1,2,4,5	3.2	6.0	2.3	4.3	0	0	0	0	0	0	0	8.40	421	0.573	2	15	0.0	0	0.00	-1.6	20.1	0	0.60	440	3.2	Y	0	0
23-Apr	195	335	1,2,4,5	2.8	5.2	2.3	4.3	0	0	0	0	0	0	0	7.80	389	0.530	2	15	0.0	0	0.00	0.0	0.0	0	0.55	403	0.0	Y	0	Baseline
23-Apr	196	335	1,2,4,5	2.8	5.2	2.3	4.3	109	7	9	33	625	39	1	7.80	321	0.437	9	20	0.0	0	0.44	17.6	14.0	5	0.46	337	16.4	Y	0	Zone 1 rear wall
23-Apr	197	335	1,2,4,5	2.8	5.2	2.3	4.3	109	7	35	134	2235	141	1	7.70	325	0.443	8	20	0.0	0	0.45	15.7	13.4	5	0.47	345	14.5	Y	0	Zone 1 all 23
23-Apr	198	335	1,2,4,5	2.8	5.2	2.3	4.3	159	10	23	85	1513	95	1	7.80	307	0.419	11	20	0.0	0	0.65	21.0	15.8	5	0.43	315	21.8	Y	0	Zone 1 front, rear
20-Apr	167	nr	nr	nr	nr	nr	nr	0	0	0	0	0	0	0	0.00	0	0.000	0	0	0.0	0	0.00	0.0	0.0	0	0	0	0.0	0	0	Baseline, no injection tests

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LONG-TERM DEMONSTRATION DATA

Date 1999	Test No.	Load MW	Mills In Serv	APH del P: APH 1	APH del P: APH 2	SNCR Injection System Operating Data: Urea gpm	Urea lpm	Water gpm	Water lpm	Sol'n gpm	Sol'n lpm	Injection Levels in Service	FERCo Gaseous Emissions Data: O_2 %	NO_x ppmc	NO_x lb/MMBtu	CO ppm	NH_3 ppm	Ash NH_3 ppm	Econ Profile Avail	CEM Gaseous Emissions Data: CO_2 %	NO_x ppmc	NO_x lb/MMBtu	COMMENTS
21-Sep	1	451	1,3-5	3.6	OOS	0.0	0	0.0	0	0.0	0	na	6.05	418	0.569	24	na	na	no	nr	nr	nr	SO_3
22-Sep	2	353	2,3,5	2.6	OOS	0.0	0	0.0	0	0.0	0	na	6.28	349	0.475	20	na	na	no	nr	nr	nr	SO_3
22-Sep	3	598	1-5	5.1	OOS	0.0	0	0.0	0	0.0	0	na	4.01	425	0.579	25	na	na	no	nr	nr	nr	SO_3
27-Sep	4	601	1-5	4.8	4.8	nr	nr	nr	nr	nr	nr	nr	4.00	429	0.584	20	na	na	yes	nr	nr	nr	Baseline
28-Sep	5	607	1-5	5.0	4.8	nr	nr	nr	nr	nr	nr	nr	4.50	439	0.598	20	na	na	yes	nr	nr	nr	Baseline
28-Sep	6	607	1-5	5.0	4.8	nr	nr	nr	nr	nr	nr	nr	4.45	345	0.469	35	4.5	na	yes	nr	nr	nr	SNCR On
28-Sep	7	607	1-5	5.0	4.8	nr	nr	nr	nr	nr	nr	nr	4.30	342	0.466	35	nr	na	yes	nr	nr	nr	SNCR On
28-Sep	8	607	1-5	5.0	4.8	nr	nr	nr	nr	nr	nr	nr	4.60	461	0.628	20	na	na	yes	nr	nr	nr	Baseline
28-Sep	9	607	1-5	5.0	4.8	nr	nr	nr	nr	nr	nr	nr	4.85	307	0.418	35	nr	na	yes	nr	nr	nr	SNCR On
28-Sep	10	607	1-5	5.0	4.8	nr	nr	nr	nr	nr	nr	nr	4.18	336	0.458	26	nr	na	yes	nr	nr	nr	SNCR On
28-Sep	11	607	1-5	5.0	4.8	nr	nr	nr	nr	nr	nr	nr	4.33	448	0.610	22	na	na	yes	nr	nr	nr	Baseline
29-Sep	12	600	1-5	4.8	4.7	nr	nr	nr	nr	nr	nr	nr	3.85	338	0.460	30	nr	na	yes	nr	nr	nr	SNCR On
29-Sep	13	600	1-5	4.8	4.7	nr	nr	nr	nr	nr	nr	nr	4.20	458	0.624	23	na	na	yes	nr	nr	nr	Baseline
29-Sep	14	599	1-5	4.8	4.7	nr	nr	nr	nr	nr	nr	nr	4.15	342	0.466	30	3.7	na	yes	nr	nr	nr	SNCR On
29-Sep	15	554	1-5	4.7	4.6	nr	nr	nr	nr	nr	nr	nr	4.50	330	0.450	30	3.4	na	yes	nr	nr	nr	SNCR On
29-Sep	16	554	1-5	4.7	4.6	nr	nr	nr	nr	nr	nr	nr	4.49	426	0.580	22	na	na	yes	nr	nr	nr	Baseline
29-Sep	17	554	1-5	4.7	4.6	nr	nr	nr	nr	nr	nr	nr	4.30	317	0.431	27	na	na	yes	nr	nr	nr	SNCR On
29-Sep	18	554	1-5	4.7	4.6	nr	nr	nr	nr	nr	nr	nr	4.40	309	0.421	30	4.0	na	yes	nr	nr	nr	SNCR On
30-Sep	19	598	1-5	4.8	4.6	nr	nr	nr	nr	nr	nr	nr	4.15	309	0.420	30	3.1	na	yes	nr	nr	nr	SNCR On
30-Sep	20	598	1-5	4.8	4.6	nr	nr	nr	nr	nr	nr	nr	4.18	429	0.584	23	na	na	yes	nr	nr	nr	Baseline
30-Sep	21	598	1-5	4.8	4.6	nr	nr	nr	nr	nr	nr	nr	4.00	322	0.439	33	na	na	yes	nr	nr	nr	SNCR On
30-Sep	22	451	2-5	3.2	3.0	nr	nr	nr	nr	nr	nr	nr	4.90	280	0.381	30	1.2	na	yes	nr	nr	nr	SNCR On
30-Sep	23	451	2-5	3.2	3.0	nr	nr	nr	nr	nr	nr	nr	5.25	382	0.520	26	na	na	yes	nr	nr	nr	Baseline
30-Sep	24	352	2-5	2.8	2.4	nr	nr	nr	nr	nr	nr	nr	6.05	285	0.388	27	na	na	yes	nr	nr	nr	SNCR On
1-Oct	25	351	1,3-5	2.8	OOS	nr	nr	nr	nr	nr	nr	nr	6.38	261	0.356	25	na	na	no	nr	nr	nr	SNCR On
1-Oct	26	351	1,3-5	2.8	OOS	nr	nr	nr	nr	nr	nr	nr	6.43	267	0.363	24	na	na	no	nr	nr	nr	SNCR On
1-Oct	27	350	1,3-5	2.8	2.7	nr	nr	nr	nr	nr	nr	nr	6.58	363	0.495	22	na	na	no	nr	nr	nr	Baseline
1-Oct	28	351	1,3-5	2.8	2.7	4.9	19	34.5	131	39.4	149	1,2	nr	nr	nr	nr	na	na	no	10.40	199	0.405	SNCR On
1-Oct	29	350	1,3-5	2.7	2.6	4.9	19	34.8	132	39.7	150	1,2	nr	nr	nr	nr	na	na	no	10.55	200	0.400	SNCR On
4-Oct	30	448	1-3,5	3.4	3.2	0.0	0	0.0	0	0.0	0	na	nr	nr	nr	nr	nr	nr	no	11.05	252	0.555	SNCR System OOS

Date 1999	Test No.	Load MW	Mills In Serv	APH del P: APH 1	APH del P: APH 2	SNCR Injection System Operating Data: Urea gpm	Urea lpm	Water gpm	Water lpm	Sol'n gpm	Sol'n lpm	Injection Levels in Service	FERCo Gaseous Emissions Data: O_2 %	NO_x ppmc	NO_x lb/MMBtu	CO ppm	NH_3 ppm	Ash NH_3 ppm	Econ Profile Avail	CEM Gaseous Emissions Data: CO_2 %	NO_x ppmc	NO_x lb/MMBtu	COMMENTS
4-Oct	31	450	1-3,5	3.4	3.3	nr	nr	nr	nr	nr	nr	1,2,3	5.28	266	0.362	27	3.0	nr	no	11.30	221	0.420	Manual Test
4-Oct	31	449	1-3,5	3.5	3.4	nr	nr	nr	nr	nr	nr	1,2,3	5.28	266	0.362	27	nr	nr	no	11.55	203	0.385	Manual Test
4-Oct	32	350	1-3,5	2.9	2.5	4.9	19	nr	nr	nr	nr	1,2	nr	nr	nr	nr	nr	50	no	10.35	179	0.390	SNCR System Auto
4-Oct	33	351	1-3,5	2.9	2.5	5.0	19	nr	nr	nr	nr	1,2	nr	nr	nr	nr	nr	nr	no	10.40	190	0.395	SNCR System Auto
5-Oct	34	350	1-3,5	2.9	2.4	5.0	19	nr	nr	nr	nr	1,2	7.50	259	0.353	20	1.9	47	no	10.65	183	0.370	Manual Test
5-Oct	35	350	1-3,5	2.8	2.4	4.9	19	nr	nr	nr	nr	1,2	nr	nr	nr	nr	nr	nr	no	10.65	187	0.375	SNCR System Auto
5-Oct	36	349	1-3,5	2.8	2.4	4.9	19	nr	nr	nr	nr	1,2	nr	nr	nr	nr	nr	nr	no	10.50	182	0.370	SNCR System Auto
5-Oct	37	349	1-3,5	2.8	2.4	4.9	19	nr	nr	nr	nr	1,2	nr	nr	nr	nr	nr	nr	no	10.45	183	0.380	SNCR System Auto
5-Oct	38	349	1-3,5	2.8	2.4	5.0	19	nr	nr	nr	nr	1,2	nr	nr	nr	nr	nr	nr	no	10.70	183	0.375	SNCR System Auto
6-Oct	39	516	1-5	4.2	3.4	nr	nr	nr	nr	nr	nr	2,3	nr	nr	nr	nr	nr	nr	no	12.00	249	0.445	SNCR System Auto
6-Oct	39	529	1-5	4.3	3.4	nr	nr	nr	nr	nr	nr	2,3	4.65	300	0.409	26	2.2	132	yes	11.75	235	0.425	Manual Test
6-Oct	40	528	1-5	4.2	3.4	nr	nr	nr	nr	nr	nr	2,3	4.70	309	0.421	24	nr	nr	yes	12.15	255	0.450	Manual Test
6-Oct	41	415	1-5	2.8	2.4	nr	nr	nr	nr	nr	nr	2,3	nr	nr	nr	nr	nr	nr	no	11.25	177	0.340	Changing load
6-Oct	42	355	1-4	2.7	2.4	4.9	19	nr	nr	nr	nr	1,2	nr	nr	nr	nr	nr	nr	no	10.70	203	0.405	SNCR System Auto
6-Oct	43	356	1-4	2.8	2.4	5.0	19	nr	nr	nr	nr	1,2	nr	nr	nr	nr	nr	nr	no	10.50	199	0.405	SNCR System Auto
7-Oct	44	595	1-5	5.4	5.2	nr	nr	nr	nr	nr	nr	2,3	3.95	328	0.447	28	3.1	226	yes	12.40	294	0.500	SNCR System Auto
7-Oct	44	599	1-5	4.8	4.7	nr	nr	nr	nr	nr	nr	2,3	nr	nr	nr	nr	nr	nr	yes	12.00	272	0.485	SNCR System Auto
7-Oct	45	532	1-5	3.9	3.6	6.5	25	nr	nr	nr	nr	2,3	nr	nr	nr	nr	nr	nr	no	12.44	235	0.405	SNCR System Auto
7-Oct	46	422	1,2,4,5	3.4	2.6	4.3	16	nr	nr	nr	nr	1,2,3	nr	nr	nr	nr	nr	nr	no	11.23	188	0.360	System dispatch
7-Oct	47	367	1,2,4,5	2.8	2	4.9	19	nr	nr	nr	nr	1,2	nr	nr	nr	nr	nr	nr	no	10.42	174	0.370	System dispatch
8-Oct	48	449	1,2,4,5	3.6	2.8	4.7	18	nr	nr	nr	nr	1,2,3	5.1	250	0.341	28	2.2	223	yes	11.47	191	0.355	Manual Test
8-Oct	49	448	1,2,4,5	3.6	2.9	4.7	18	nr	nr	nr	nr	1,2,3	nr	nr	nr	nr	nr	nr	no	11.12	194	0.375	System dispatch
8-Oct	50	450	1,2,4,5	3.6	2.8	4.7	18	nr	nr	nr	nr	1,2,3	nr	nr	nr	nr	nr	nr	no	11.28	179	0.340	System dispatch
8-Oct	51	451	1,2,4,5	3.7	2.8	4.4	17	nr	nr	nr	nr	1,2,3	nr	nr	nr	nr	nr	nr	no	10.77	182	0.365	System dispatch
11-Oct	52	340	1,2,3,5	3.0	2.2	4.8	18	25.0	95	29.8	113	1,2	6.90	230	0.314	5	4.9	252.0	Y	nr	nr	nr	Planned Test
11-Oct	53	332	1,2,3,5	3.0	2.4	4.0	15	21.0	79	25.0	95	1,2	6.90	230	0.314	5	nr	nr	N	nr	nr	nr	Load Follow
11-Oct	54	340	1,2,3,5	2.8	2.2	4.4	17	26.0	98	30.4	115	1,2	7.40	245	0.334	5	nr	nr	N	nr	nr	nr	Load Follow
11-Oct	55	341	1,2,3,5	2.8	2.2	3.4	13	26.0	98	29.4	111	1,2	7.35	240	0.327	5	nr	nr	N	nr	nr	nr	Load Follow
12-Oct	56	453	1,2,3,5	3.9	4	5.0	19	33.0	125	38.0	144	1,2,3	6.30	269	0.367	10	4.5	191.0	Y	nr	nr	nr	Planned Test
12-Oct	57	448	1,2,3,5	3.6	3.4	5.0	19	33.0	125	38.0	144	1,2,3	6.30	269	0.367	10	nr	nr	N	nr	nr	nr	Load Follow
12-Oct	58	350	1,2,3,5	3.0	2.3	4.0	15	25.0	95	29.0	110	1,2	7.30	250	0.340	15	nr	nr	N	nr	nr	nr	Load Follow

						SNCR INJECTION SYSTEM OPERATING DATA							FERCo GASEOUS EMISSIONS DATA							CEM GASEOUS EMISSIONS DATA			
						Urea		Water		Sol'n		Injection Levels						Ash	Econ				
Date	Test	Load	Mills	APH del P									O_2	NO_x	NO_x	CO	NH_3	NH_3	Profile	CO_2	NO_x	NO_x	
1999	No.	MW	In Serv	APH 1	APH 2	gpm	lpm	gpm	lpm	gpm	lpm	in Service	%	ppmc	lb/MMBtu	ppm	ppm	ppm	Avail	%	ppmc	lb/MMBtu	COMMENTS
12-Oct	59	349	1,2,3,5	3.0	2.4	4.5	17	25.0	95	29.5	112	1,2	7.30	250	0.340	15	nr	nr	N	nr	nr	nr	Load Follow
13-Oct	60	533	1,2,3,5	5.0	5	6.0	23	30.0	114	36.0	136	2,3	4.75	210	0.315	15	7.0	204.3	Y	nr	nr	nr	Derate Due To
13-Oct	61	535	1,2,3,5	4.6	4.8	6.0	23	30.0	114	36.0	136	2,3	4.80	210	0.321	15	nr	nr	N	nr	nr	nr	#4 Mill O/S
13-Oct	62	533	1,2,3,5	4.5	4.6	5.0	19	27.0	102	32.0	121	2,3	4.65	255	0.356	15	nr	nr	N	nr	nr	nr	Load Follow
13-Oct	63	465	1,2,3,5	3.5	3.7	5.0	19	34.0	129	39.0	148	1,2,3	6.10	224	0.305	15	nr	nr	N	nr	nr	nr	Load Follow
14-Oct	64	352	1,2,3	3.8	2.6	5.0	19	24.0	91	29.0	110	1,2	6.75	233	0.319	10	2.0		Y	nr	nr	nr	Planned Test
14-Oct	65	344	1,2,3,4	3.6	2.6	5.0	19	23.0	87	28.0	106	1,2	6.75	233	0.319	10	nr	nr	N	nr	nr	nr	Planned Test
14-Oct	66	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	N	nr	nr	nr	Load Follow
25-Oct	68	600	all	5.5	5.6	9.0	34	31.0	117	40.0	151	2,3	nr	nr	nr	nr	6.9	391.3	N	nr	272	0.485	Planned Test
25-Oct	69	603	all	5.5	5.4	9.0	34	31.0	117	40.0	151	2,3	nr	nr	nr	nr	nr	nr	N	nr	284	0.510	Planned Test
25-Oct	70	600	all	5.7	5.5	9.0	34	31.0	117	40.0	151	2,3	nr	nr	nr	nr	nr	nr	N	nr	291	0.520	Load Follow
25-Oct	71	512	all	4.5	4.5	5.0	19	29.0	110	34.0	129	2,3	nr	nr	nr	nr	nr	nr	N	nr	219	0.410	Load Follow
26-Oct	72	618	all	5.9	5.8	9.0	34	33.0	125	42.0	159	2,3	nr	nr	nr	nr	8.7	133.3	N	nr	286	0.515	Load reduced
26-Oct	73	520	all	4.3	4.4	7.0	26	24.0	91	31.0	117	2,3	nr	nr	nr	nr	nr	nr	N	nr	270	0.505	During Testing
26-Oct	74	335	2,3,5	2.6	2.6	5.0	19	23.0	87	28.0	106	1,2	nr	nr	nr	nr	nr	nr	N	nr	198	0.410	Load Follow
26-Oct	75	340	2,3,5	2.7	2.7	5.0	19	23.0	87	28.0	106	1,2	nr	nr	nr	nr	nr	nr	N	nr	201	0.420	Load Follow
27-Oct	76	618	all	6.0	5.3	7.2	27	35.0	132	42.2	160	2,3	nr	nr	nr	nr	8.4	76.5	N	nr	251	0.460	Planned Test
27-Oct	77	618	all	5.8	5.4	7.0	26	35.0	132	42.0	159	2,3	nr	nr	nr	nr	nr	nr	N	nr	255	0.460	6 Burner Lines OOS
27-Oct	78	619	all	5.7	5.6	6.0	23	37.0	140	43.0	163	2,3	nr	nr	nr	nr	nr	nr	N	nr	258	0.460	See Above
28-Oct	79	450	all	3.2	3.2	5.0	19	27.0	102	32.0	121	1,2,3	nr	nr	nr	nr	2.1	176.5	N	nr	217	0.400	Planned Test
28-Oct	80	451	all	3.3	3.3	5.0	19	27.0	102	32.0	121	1,2,3	nr	nr	nr	nr	nr	nr	N	nr	224	0.410	Planned Test
28-Oct	81	451	all	3.3	3.4	5.0	19	27.0	102	32.0	121	1,2,3	nr	nr	nr	nr	nr	nr	N	nr	226	0.410	Planned Test
29-Oct	82	602	all	5.6	5.4	6.0	23	28.0	106	34.0	129	2,3	nr	nr	nr	nr	nr		N	nr	226	0.410	Planned Test
29-Oct	83	594	all	5.5	5.3	7.0	26	35.0	132	42.0	159	2,3	nr	nr	nr	nr	nr	nr	N	nr	240	0.440	Limited Time
29-Oct	84	418	2,3,4,5	3.3	3.1	5.0	19	24.0	91	29.0	110	1,2,3	nr	nr	nr	nr	nr	nr	N	nr	199	0.400	Load Follow
1-Nov	85	348	1-4	3.4	2.8	5.0	19	31.1	118	36.1	137	1,2	nr	nr	nr	nr	0.0		No	10.00	nr	nr	Scheduled Test
1-Nov	86	357	1-4	3.5	2.8	4.9	19	31.8	120	36.7	139	1,2	nr	nr	nr	nr	nr	257.7	No	10.41	203	0.42	Load Follow
1-Nov	87	355	1-4	3.4	2.7	4.9	18	32.4	123	37.3	141	1,2	nr	nr	nr	nr	nr		No	10.54	204	0.42	Load Follow
1-Nov	88	360	1-4	3.3	2.7	5.0	19	31.3	119	36.3	137	1,2	nr	nr	nr	nr	nr		No	10.42	203	0.42	Load Follow
1-Nov	89	363	1-4	3.3	2.7	4.9	18	31.4	119	36.3	137	1,2	nr	nr	nr	nr	nr		No	10.43	202	0.42	Load Follow

						SNCR INJECTION SYSTEM OPERATING DATA							FERCo GASEOUS EMISSIONS DATA							CEM GASEOUS EMISSIONS DATA			
				APH del P		Urea		Water		Sol'n		Injection Levels	O_2	NO_x	NO_x	CO	NH_3	Ash NH_3	Econ Profile	CO_2	NO_x	NO_x	
Date 1999	Test No.	Load MW	Mills In Serv	APH 1	APH 2	gpm	lpm	gpm	lpm	gpm	lpm	in Service	%	ppmc	lb/MMBtu	ppm	ppm	ppm	Avail	%	ppmc	lb/MMBtu	COMMENTS
2-Nov	90	352	1-4	3.2	2.4	5.0	19	30.8	117	35.8	136	1,2	nr	nr	nr	nr	nr		No	10.70	185	0.370	Load Follow
2-Nov	91	600	1-5	6.9	5.6	6.7	25	32.4	122	39.0	148	2,3	nr	nr	nr	nr	nr	89.0	No	12.04	233	0.415	Load Follow
2-Nov	92	385	1,3-5	3.7	2.8	5.0	19	32.3	122	37.2	141	1,2	nr	nr	nr	nr	0.0		No	10.38	184	0.380	Scheduled Test
2-Nov	93	379	1,3-5	3.8	2.8	5.0	19	32.7	124	37.6	142	1,2	nr	nr	nr	nr	nr		No	10.58	188	0.385	Scheduled Test
3-Nov	94	618	1-5	7.0	6.2	7.7	29	36.0	136	43.6	165	2,3	nr	nr	nr	nr	0.0		No	12.35	285	0.495	Scheduled Test
3-Nov	95	618	1-5	6.8	6.1	6.4	24	34.1	129	40.5	153	2,3	nr	nr	nr	nr	nr		No	12.67	288	0.485	Scheduled Test
3-Nov	96	620	1-5	7.0	6.2	6.8	26	33.4	126	40.2	152	2,3	nr	nr	nr	nr	nr	166.0	No	12.93	303	0.505	Load Follow
3-Nov	97	514	1-5	4.7	3.8	5.0	19	24.6	93	29.6	112	2,3	nr	nr	nr	nr	nr		No	12.59	256	0.435	Transient
3-Nov	98	345	1-3,5	3.7	2.8	4.9	19	31.7	120	36.6	139	1,2	nr	nr	nr	nr	nr		No	10.16	171	0.360	Load Follow
4-Nov	99	613	1-5	6.8	6.0	5.3	20	36.3	137	41.6	157	2,3	nr	nr	nr	nr	0.0		No	12.33	307	0.535	CEM RATA
4-Nov	100	616	1-5	6.7	6.1	4.4	16	37.7	143	42.0	159	2,3	nr	nr	nr	nr	nr		No	12.00	300	0.535	CEM RATA
4-Nov	101	610	1-5	6.6	6.0	5.9	22	35.6	135	41.5	157	2,3	nr	nr	nr	nr	nr	106.3	No	11.96	300	0.540	CEM RATA
4-Nov	102	620	1-5	6.6	5.8	5.3	20	36.4	138	41.7	158	2,3	nr	nr	nr	nr	nr		No	11.69	287	0.530	CEM RATA
4-Nov	103	378	2-5	3.8	3.4	5.0	19	41.9	158	46.9	178	1,2	nr	nr	nr	nr	nr		No	10.95	215	0.420	Load Follow
5-Nov	104	351	2-5	3.3	2.6	4.9	19	31.3	118	36.2	137	1,2	nr	nr	nr	nr	0.0		No	10.10	175	0.365	Scheduled Test
5-Nov	105	347	2-5	3.2	2.8	5.0	19	31.3	119	36.3	137	1,2	nr	nr	nr	nr	nr		No	nr	184	0.375	Scheduled Test
5-Nov	106	341	2-5	3.1	2.6	4.9	19	31.3	118	36.2	137	1,2	nr	nr	nr	nr	nr		No	10.57	176	0.360	Load Follow
5-Nov	107	343	2-5	3.3	2.6	5.0	19	31.2	118	36.2	137	1,2	nr	nr	nr	nr	nr		No	10.42	180	0.370	Load Follow
5-Nov	108	347	2-5	3.2	2.6	5.0	19	31.2	118	36.1	137	1,2	nr	nr	nr	nr	nr		No	10.46	182	0.337	Load Follow
8-Nov	109	351	2-5	3.6	2.7	4.9	19	31.0	117	35.9	136	1,2	nr	nr	nr	nr	nr	nr	no	10.54	191	0.385	Load Follow
8-Nov	110	510	1-5	5.5	4.0	4.7	18	28.5	108	33.1	125	2,3	nr	nr	nr	nr	nr	nr	no	11.67	219	0.405	Load Follow
8-Nov	111	370	1,3-5	3.9	3.2	4.1	15	33.9	128	38.0	144	1,2	nr	nr	nr	nr	0.0	nr	no	10.84	165	0.330	Scheduled Test
8-Nov	112	370	1,3-5	3.7	2.8	4.8	18	32.5	123	37.3	141	1,2	nr	nr	nr	nr	nr	0	no	10.83	183	0.365	Scheduled Test
8-Nov	113	370	1,3-5	3.7	2.8	5.1	19	31.9	121	37.0	140	1,2	nr	nr	nr	nr	nr	nr	no	10.71	185	0.370	Load Follow
9-Nov	114	452	1,3-5	4.4	3.7	4.8	18	32.5	123	37.3	141	1,2,3	nr	nr	nr	nr	0.0	nr	no	11.15	212	0.410	Scheduled Test
9-Nov	115	445	1,3-5	4.4	3.7	4.2	16	33.4	126	37.6	142	1,2,3	nr	nr	nr	nr	nr	0	no	11.22	200	0.380	Scheduled Test
9-Nov	116	450	1,3-5	4.4	3.5	0.0	0	0.0	0	0.0	0	na	nr	nr	nr	nr	nr	nr	no	11.16	266	0.510	Load Follow
9-Nov	117	344	1,3-5	3.2	2.5	3.8	14	33.0	125	36.8	139	1,2	nr	nr	nr	nr	nr	nr	no	10.31	156	0.330	SNCR system OOS
9-Nov	118	341	1,3-5	3.3	2.6	4.3	16	32.2	122	36.5	138	1,2	nr	nr	nr	nr	nr	nr	no	10.23	172	0.360	Load Follow
10-Nov	119	351	1-4	3.3	2.7	5.4	20	30.0	114	35.4	134	1,2	nr	nr	nr	nr	0.0	0	no	10.34	195	0.405	Scheduled Test
10-Nov	120	353	1-4	3.4	2.7	5.4	20	30.3	115	35.7	135	1,2	nr	nr	nr	nr	nr	nr	no	10.47	195	0.420	Load Follow

						SNCR INJECTION SYSTEM OPERATING DATA							FERCo GASEOUS EMISSIONS DATA							CEM GASEOUS EMISSIONS DATA			
Date	Test	Load	Mills	APH del P		Urea		Water		Sol'n		Injection Levels	O_2	NO_x	NO_x	CO	NH_3	Ash NH_3	Econ Profile	CO_2	NO_x	NO_x	
1999	No.	MW	In Serv	APH 1	APH 2	gpm	lpm	gpm	lpm	gpm	lpm	in Service	%	ppmc	lb/MMBtu	ppm	ppm	ppm	Avail	%	ppmc	lb/MMBtu	COMMENTS
10-Nov	121	353	1-4	3.4	2.7	4.8	18	30.8	116	35.6	135	1,2	nr	nr	nr	nr	nr	nr	no	10.40	208	0.423	Load Follow
10-Nov	122	352	1-4	3.4	2.7	4.9	18	30.5	115	35.3	134	1,2	nr	nr	nr	nr	nr	nr	no	10.31	209	0.435	Load Follow
10-Nov	123	351	1-4	3.5	2.7	4.8	18	30.3	115	35.1	133	1,2	nr	nr	nr	nr	nr	nr	no	10.19	209	0.440	Load Follow
11-Nov	124	358	1-4	3.3	2.6	5.0	19	30.7	116	35.7	135	1,2	nr	nr	nr	nr	nr	nr	no	10.55	218	0.445	Load Follow
11-Nov	125	472	1-4	4.2	3.5	5.2	20	34.2	129	39.4	149	1,2,3	nr	nr	nr	nr	0.0	nr	no	11.55	228	0.425	Scheduled Test
11-Nov	126	473	1-4	4.2	2.5	5.0	19	36.0	136	41.0	155	1,2,3	nr	nr	nr	nr	nr	nr	no	11.36	207	0.390	Scheduled Test
11-Nov	127	356	1-4	3.3	2.7	4.3	16	32.4	122	36.7	139	1,2	nr	nr	nr	nr	nr	0	no	10.50	186	0.380	Load Follow
11-Nov	128	356	1-4	3.2	2.7	4.3	16	32.0	121	36.3	137	1,2	nr	nr	nr	nr	nr	nr	no	10.70	193	0.390	Load Follow
11-Nov	129	356	1-4	3.4	2.7	5.2	20	31.2	118	36.4	138	1,2	nr	nr	nr	nr	nr	nr	no	10.57	199	0.400	Load Follow
12-Nov	130	559	1-5	6.1	4.5	4.9	19	30.1	114	35.0	132	2,3	nr	nr	nr	nr	0.0	nr	no	11.88	273	0.490	Scheduled Test
12-Nov	131	553	1-5	5.7	5.1	4.2	16	33.0	125	37.2	141	2,3	nr	nr	nr	nr	nr	0	no	11.93	246	0.445	Scheduled Test
12-Nov	132	550	1-5	5.7	5.1	4.8	18	32.7	124	37.5	142	2,3	nr	nr	nr	nr	nr	nr	no	11.91	249	0.445	Load Follow
12-Nov	133	533	1-5	5.1	4.2	4.8	18	31.7	120	36.5	138	2,3	nr	nr	nr	nr	nr	nr	no	11.98	214	0.390	Load Follow
12-Nov	134	350	2-5	3.0	2.4	4.1	16	33.0	125	37.1	140	1,2	nr	nr	nr	nr	nr	nr	no	10.84	173	0.345	Load Follow
15-Nov	135	609	1-5	6.8	6.4	0.0	0	0.0	0	0.0	0	na	nr	nr	nr	nr	nr	nr	no	12.17	339	0.605	AEP Test
15-Nov	136	610	1-5	6.7	6.2	0.0	0	0.0	0	0.0	0	na	nr	nr	nr	nr	nr	nr	no	12.02	329	0.585	AEP Test
15-Nov	137	610	1-5	6.8	6.2	0.0	0	0.0	0	0.0	0	na	nr	nr	nr	nr	nr	nr	no	12.16	350	0.615	AEP Test
15-Nov	138	609	1-5	6.6	6.2	0.0	0	0.0	0	0.0	0	na	nr	nr	nr	nr	nr	nr	no	12.36	346	0.600	AEP Test
15-Nov	139	610	1-5	6.7	6.2	0.0	0	0.0	0	0.0	0	na	nr	nr	nr	nr	nr	nr	no	12.28	343	0.600	AEP Test
15-Nov	140	610	1-5	6.4	5.8	0.0	0	0.0	0	0.0	0	na	nr	nr	nr	nr	nr	nr	no	12.29	342	0.600	AEP Test
16-Nov	141	619	1-5	6.3	5.2	nr	nr	nr	nr	44.2	167	2,3	nr	nr	nr	nr	nr	nr	no	12.17	291	0.510	Scheduled Test
16-Nov	142	618	1-5	6.7	5.3	nr	nr	nr	nr	44.3	168	2,3	nr	nr	nr	nr	nr	nr	no	11.99	295	0.530	Scheduled Test
16-Nov	143	616	1-5	6.6	5.1	nr	nr	nr	nr	42.7	162	2,3	nr	nr	nr	nr	nr	nr	no	12.22	296	0.530	Scheduled Test
16-Nov	144	618	1-5	6.5	5.2	nr	nr	nr	nr	44.3	168	2,3	nr	nr	nr	nr	nr	nr	no	12.17	299	0.530	System Dispatch
17-Nov	145	575	1-5	5.2	3.9	nr	nr	nr	nr	41.7	158	2,3	nr	nr	nr	nr	nr	nr	no	12.05	265	0.470	System Dispatch
17-Nov	146	377	1,2,4,5	3.2	2.4	4.6	17	19.3	73	23.9	90	1,2	nr	nr	nr	nr	nr	nr	no	10.76	148	0.295	System Dispatch
17-Nov	147	347	1,2,4,5	3.2	2.4	3.8	14	30.3	115	34.1	129	1,2	nr	nr	nr	nr	nr	nr	no	10.36	162	0.340	System Dispatch
17-Nov	148	347	1,2,4,5	3.1	2.6	4.1	16	30.3	115	34.4	130	1,2	nr	nr	nr	nr	nr	nr	no	10.15	163	0.340	System Dispatch
17-Nov	149	347	1,2,4,5	3.2	2.6	4.5	17	29.7	113	34.2	129	1,2	nr	nr	nr	nr	nr	nr	no	9.63	159	0.355	System Dispatch
18-Nov	150	375	1,3-5	3.6	2.6	4.8	18	30.0	113	34.8	132	1,2	nr	nr	nr	nr	nr	nr	no	10.71	206	0.415	System Dispatch
18-Nov	151	345	1,3-5	3.4	2.4	4.8	18	28.5	108	33.3	126	1,2	nr	nr	nr	nr	nr	nr	no	10.50	196	0.405	System Dispatch

Date	Test	Load	Mills	APH del P		SNCR INJECTION SYSTEM OPERATING DATA							FERCo GASEOUS EMISSIONS DATA					Ash	Econ	CEM GASEOUS EMISSIONS DATA			
						Urea		Water		Sol'n		Injection Levels	O_2	NO_x	NO_x	CO	NH_3	NH_3	Profile	CO_2	NO_x	NO_x	
1999	No.	MW	In Serv	APH 1	APH 2	gpm	lpm	gpm	lpm	gpm	lpm	in Service	%	ppmc	lb/MMBtu	ppm	ppm	ppm	Avail	%	ppmc	lb/MMBtu	COMMENTS
18-Nov	152	344	1,3-5	3.3	2.5	5.1	19	27.9	105	33.0	125	1,2	nr	nr	nr	nr	nr	nr	no	10.53	191	0.390	System Dispatch
19-Nov	153	360	1,3-5	3.7	2.7	5.2	20	27.9	106	33.1	125	1,2	nr	nr	nr	nr	nr	nr	no	10.11	201	0.430	System Dispatch
19-Nov	154	361	1,3-5	3.6	2.6	5.1	19	28.2	107	33.3	126	1,2	nr	nr	nr	nr	nr	nr	no	10.33	195	0.405	System Dispatch
19-Nov	155	353	1,3-5	3.6	2.6	5.1	19	28.3	107	33.4	126	1,2	nr	nr	nr	nr	nr	nr	no	10.34	182	0.375	System Dispatch