RCRA Box 1475

Prepped by Candice Davis

Document Number:

1) II-I-57

Docket Number:

A-95-28

Docket No. A-95-28
Item No. II-I-57

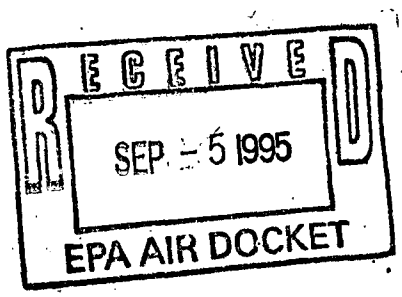
May 1995

EPRI
Electric Power
Research Institute

EPA

EPRI/EPA 1995 Joint Symposium on Stationary Combustion NO_x Control

Book 1: Tuesday, May 16, 1995
Sessions 1, 2, 3



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U.S. Environmental Protection Agency
Air and Energy Engineering Research Laboratory
Combustion Research Branch

May 16–19, 1995
Hyatt Regency Crown Center
Kansas City, Missouri

PERFORMANCE OF A CONTROLLED FLOW/ SPLIT FLAME LOW-NOx BURNER SYSTEM ON A TANGENTIALLY FIRED BOILER

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Abstract

Topic presented is the performance of a controlled flow, split flame, low NOx burner system installed on a tangentially-fired furnace, identifying specifically the results of both short term optimization testing and long term emission monitoring. This installation was the first time application of the controlled-flow, split-flame (CF/SF) low-NOx burner design used on wall fired boilers, to a boiler having a tangential firing design. Installation of this low NOx burner system to the furnace occurred without the modification of waterwalls, or addition of separated overfire air. Technical benefit achieved is reduction of fuel NOx production on a per burner basis in a tangentially-fired boiler, with the burners operating at near stoichiometric conditions. Combination of optimized burners along with vertical secondary air staging was found to provide the desired emission reduction over the entire boiler load range. Ash LOI and unit efficiency values were found to remain consistent with pre conversion, baseline data values.

Introduction

A first time demonstration project involving retrofit low NOx burners was undertaken beginning in 1992 on the 310 MW, Unit 7 boiler at Wisconsin Electric's Oak Creek Power Plant, which is located 20 miles south of Milwaukee on Lake Michigan. This demonstration project has been a joint effort between Foster Wheeler Energy Corporation (FWEC) and the Wisconsin Electric Power Company (WEPCo).

The Unit 7 boiler at Oak Creek Power Plant is designated as a Phase I unit under the 1990 Amendments to the Clean Air Act. The goal was to reduce NOx emissions on this unit to less than 0.45 lb./MBtu by January 1, 1995, with minimal impact on LOI and unit efficiency. Baseline

readings taken prior to conversion in 1992 indicated that a 30 to 40 percent reduction in NOx emissions would be needed across the entire load range to achieve this goal.

The objective of the demonstration project was to achieve the required emission reduction and to confirm the adaptability of wall-fired low-NOx burner technology to a tangentially fired furnace by developing a commercially offered tangential low NOx burner (TLNB) system. To accomplish this objective, all of the original burners were replaced with retrofit burners of a prototype design in the Spring of 1992. A production burner system was developed based upon the experience gained from eighteen months of operational testing of the prototype TLN burners, and was installed to replace the prototype burners on Unit 7 during a scheduled turbine overhaul outage in the spring of 1994. Table I provides a chronology of project phases.

TABLE I
CHRONOLOGY OF PROJECT PHASES

Test Phase	Activity	Time Period
Baseline Testing	a. Obtain baseline data	Dec. 1991 -Jan. 1992
Prototype TLNB	a. Original Burner Removal and Prototype TLN Burners Installed	Feb. 7 - May 29, 1992
	b. Testing Prototype TLN Burners Alone	July - Aug. 1992
	c. Testing Prototype TLN Burners W/SAS* (*Secondary Air Staging created through idle top burners)	Sept. - Oct. 1992
	d. Duplication of above prototype tests on state sulfur compliance coal	Nov. - Dec. 1992
TLNB System	a. Removal of Prototype TLNB & Installation of Production TLNB System	Nov. 29, 1993 - Mar. 7, 1994
	b. TLNB System initial optimization period	Mar. 7 - June 1, 1994
	c. TLNB System final optimization period	Oct. - Dec. 1994
	d. TLNB System installed on Oak Creek Unit 8.	Jan. - April 1995

Unit Description

Oak Creek Unit 7 has a four corner, tangentially-fired, pulverized coal furnace of controlled circulation design. Manufactured by Combustion Engineering Corp. in 1965 as a pressurized furnace, the unit was converted to balanced draft in 1970. The boiler is rated at 2×10^6 lbs/hr. evaporation at 2,620 psig, with steam conditions of 1050/1000 ^{o}F for the superheat/reheat temperatures. Twenty pulverized coal burners, on five levels, are supplied by five CE model RPS 683 bowl mills of a pressurized-exhauster design. Auxiliary start-up and coal ignition fuel was switched during the subject burner retrofit from two levels of oil to five levels of gas.

TLN Burner Description

The windbox is partitioned with division plates. Flow is regulated for each partitioned burner lane by a secondary air damper and proportioned into three zones to create staging at the burner. The controlled flow is measured by flow elements installed in the primary and secondary air systems. The flow to the secondary air staging level and burners is shown schematically in Figure 1. The tip of the burner has a tilting split flame design. Arrangement of a single burner cell is shown in Figures 1 and 2.

Figure 1
TYPICAL SECONDARY AIR SYSTEM FOR A TLN BURNER MODULE

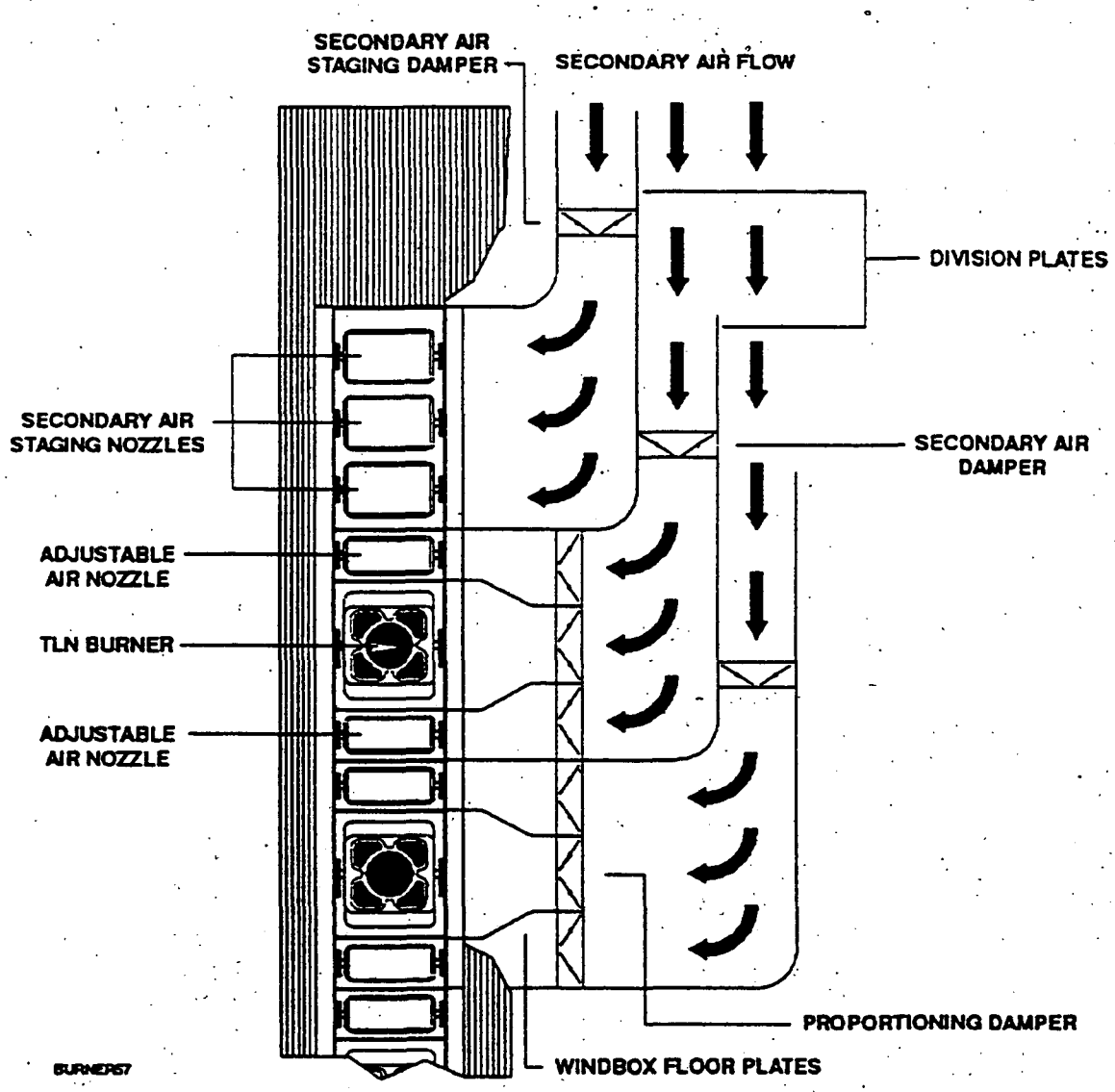


Figure 2
TYPICAL CORNER ARRANGEMENT OF TLN BURNER MODULE

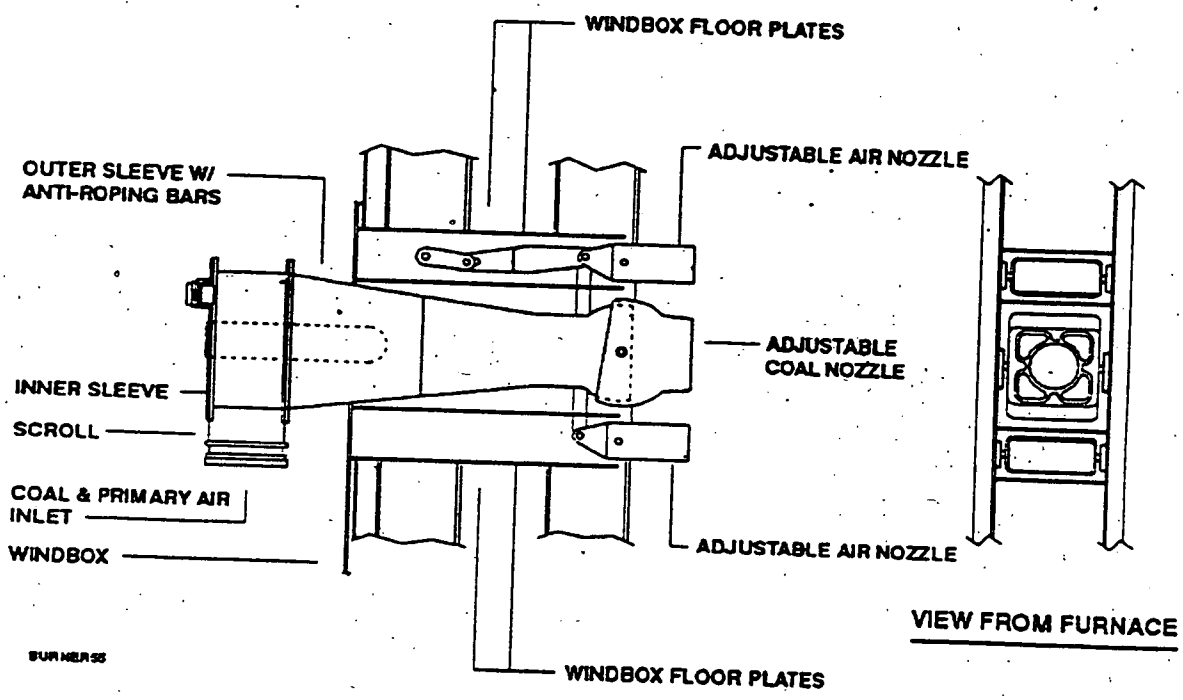
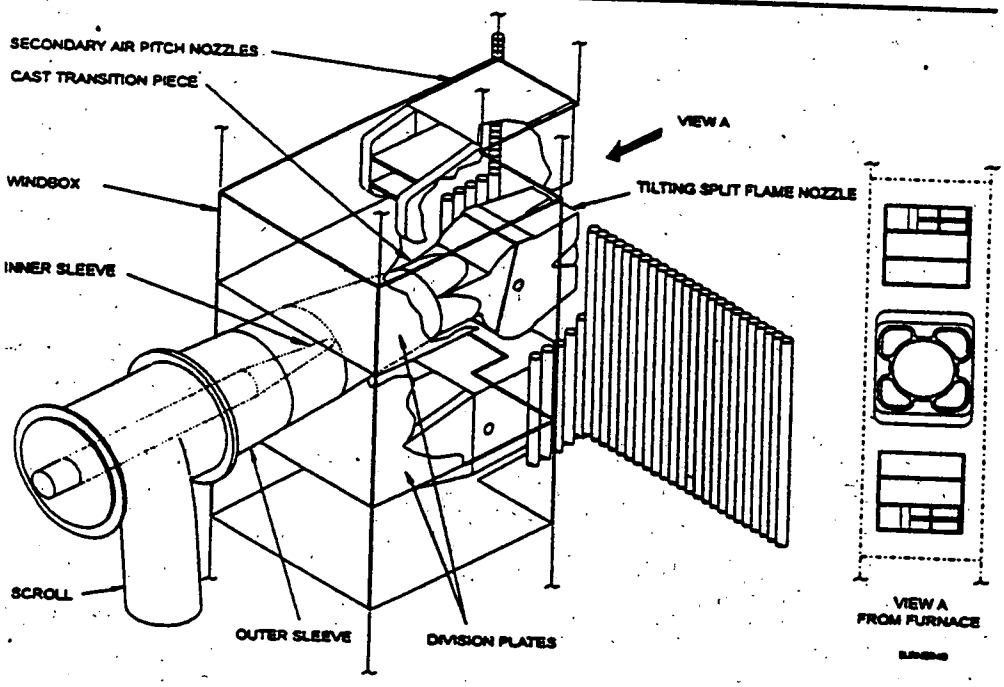


Figure 3
TANGENTIALLY FIRED LOW NOx BURNER (TLN)
MODULE ARRANGEMENT



Performance

Initial Comparison

Table II shows a comparison of the baseline operating data with the prototype TLNB system. This is provided for comparison of unit operating data to show that there was little or no change from the acceptable baseline, pre conversion test data, when operating on the midwestern bituminous coal fired during the testing of the prototype TLN burners.

TABLE II
BOILER PERFORMANCE COMPARATIVE DATA ON MIDWESTERN BITUMINOUS COAL
BASELINE VERSUS PROTOTYPE TLNB

Parameter	Baseline	TLNB
Load (MW)	300	300
FW Flow (KPPH)	1816	1824
SH Spray (KPPH)	53	42
RH Spray (KPPH)	40	46
Throttle Press.(psig)	2402	2404
MS Temp.(^{o}F)	1061	1043
RH Temp. (^{o}F)	1013	1003
NO_x (lb/10_6 Btu)	0.68	0.38
Unburned Carbon(%)	9.19 @ 4.2% O_2	8.0 @ 3.5% O_2
CO (ppm)	20 - 40	20 - 40

Performance Following 1992 Coal Change

Coal was switched in the fall of 1992 from midwestern bituminous (1.6 percent sulfur, 6.8 percent ash, and HHV of 13,850 Btu/lb.) to a western bituminous coal (0.6 percent sulfur, 13 percent ash, and HHV of 13,000 Btu/lb.). This was to comply with a state fuel sulfur limit. Volatiles and fixed carbon for both coals were similar.

A change in performance was seen on all four furnaces at Oak Creek. On Oak Creek 8, the "sister" unit to Oak Creek Unit 7, which had not been modified to a low NOx burner system, it was noted that the spray requirements were diminished. Inability to repeatedly obtain desired reheat and superheat temperatures on Unit 7 was observed. Ash deposits on the furnace walls were noted to be drier and less adherent to the walls. The sheets of dry ash were also noted to be "self shedding." A problem in the prototype burner tilts restricted effective temperature control.

Performance of Production TLN Burner System

Burner Tilts. Improvements in the coal nozzle tilt design permitted the production burners to achieve the design steam temperatures by means of controlled burner nozzle tilt.

Ash Deposits. The ash deposit pattern in the furnace was noted to have changed from the baseline, pre conversion pattern. The furnace walls were notably cleaner, and with the stable low NOx burner ignition point being closer to the burners, there is a feeling that more heat is being

absorbed by the waterwalls. Flyash LOI was similar to values on the non-converted sister unit, Oak Creek Unit 8, and averaged in the range of 3 to 5 percent LOI.

Ash Characteristics. The original higher excess oxygen carried on the pre conversion furnace of 4.2% O_2, provided a much more radiant fire, and the ash on the walls from the midwestern coal was noted to glaze and become more adherent to the tubes than the drier western coal ash.

Steam Temperatures. Selective soot blowing of the rear convective superheat elements, along with the furnace exit aperture reheat bundles, was found to enable design steam temperatures of 1050 ^{o}F/1000 ^{o}F (superheat/reheat) to be maintained at full load. Temperatures are not a problem at low load. Soot blowing in the furnace was found to reduce steam temperatures.

Exit Oxygen and Furnace Temperature Profiles. The furnace exit oxygen and steam temperature profiles across the furnace are more even following the balancing of air flows to each burner. Evidence of a more uniform gas flow was confirmed by the lack of a higher ash wear area that had typically been observed during outages on the pre-conversion furnace.

Flame Stability. Balancing of air flows to each burner also resulted in more stable flames at low load and eliminated what is referred to as "cold corners", which were burners on the pre-conversion unit that had an ignition point farther from the corner.

Emission Test Results

Short Term, Single Point Test Results

Table III shows the best repeatable results obtained for the short term, single load point optimization testing. Single point tests were each two hours in length with the a test variable controlled. A test matrix was followed to determine the effects of altering the test variable. All end of day tests were repeated on the following day of testing to ascertain that conditions could be repeated. A total of 152 tests were conducted on 70 non-consecutive test dates to define the response of the new burner system to variations in adjustable parameters.

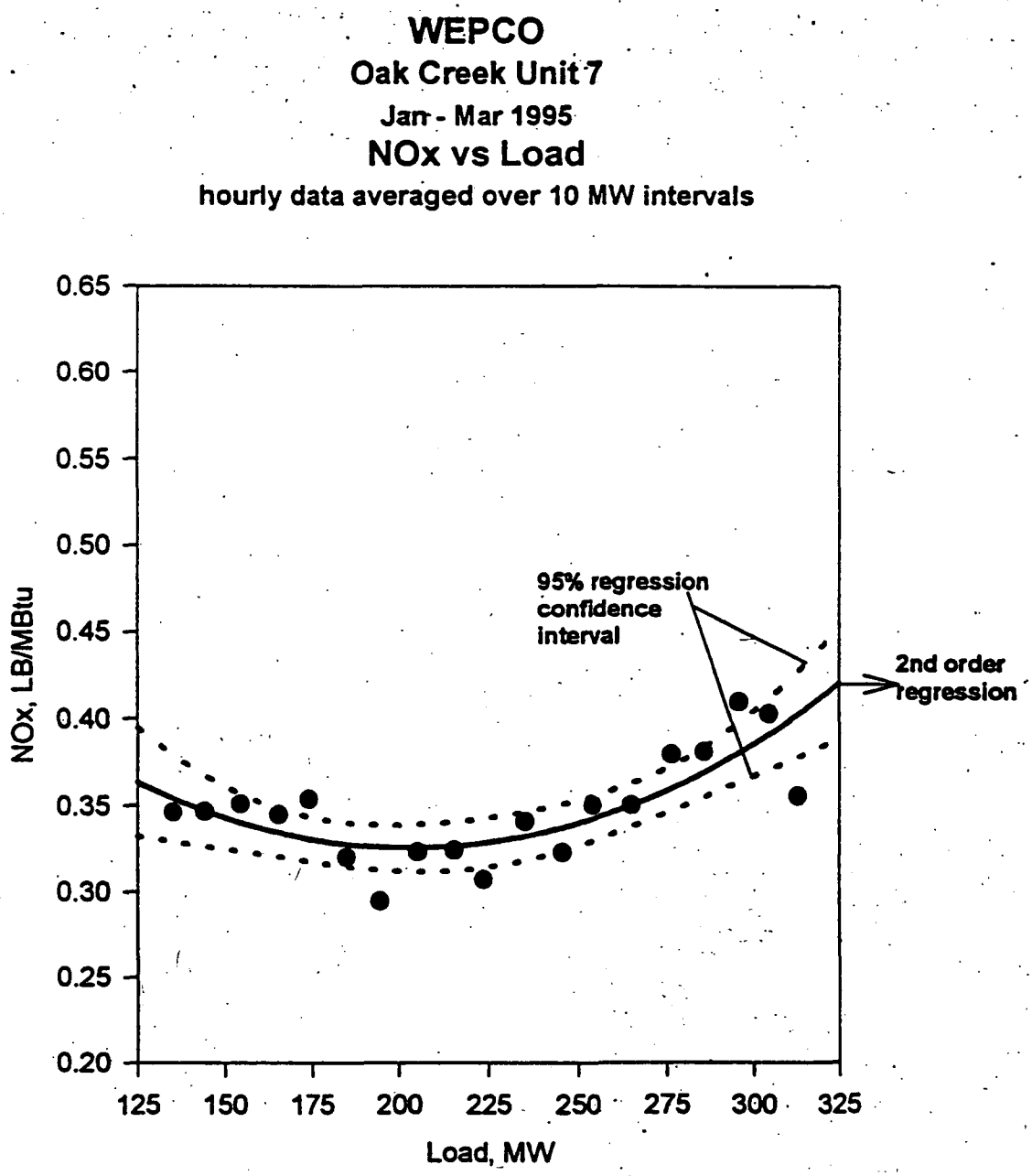
TABLE III
OAK CREEK UNIT 7 TLN BURNER DEMONSTRATION RESULTS SUMMARY
NO_x (lb/MBtu) EMISSIONS VERSUS LOAD (MW) COMPARISON

	NO_x Emissions lb./MBtu		
Test Phase (Dates)	**Low Load (125 MW)**	**Medium Load (230-260 MW)**	**Full Load (260-300 MW)**
Baseline (pre conversion) (12/91 - 1/92)	0.67	0.61	0.68
Production TLNB - (3/94 - 12/94)	0.31	0.28	0.35

Long Term Emission Test Results

Table IV displays the unit CEM hourly averages at each 10 megawatt load point along the daily load curve of Oak Creek Unit 7 for the period of January 1, 1995 to March 15, 1995. The data for this 74 day period was obtained from certified stack CEM data. For comparison, the rolling hourly average for the unit during the first two months of 1995 was 0.364 lbs.NOx/mmBtu.

Table IV



Conclusion

The goals of the demonstration project have been achieved. A production burner system was developed and unit performance has been acceptable while achieving low NOx emissions. Final tuning of boiler controls is in progress. Conversion of the similar Oak Creek Unit 8 tangentially fired furnace to an identical low NOx burner system has been accomplished and that unit is going into service in mid - April 1995.

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