BEFORE THE ILLINOIS POLLUTION CONTROL BOARD
OF THE STATE OF ILLINOIS

MIDWEST GENERATION, LLC Low NOx Burner System with Separated Over-fire Air System for Waukegan Station, Unit No. 7	)	PCB 14- (Tax Certification - Air)
PROPERTY IDENTIFICATION NUMBER 08-15-200-006 or portion thereof	)	

NOTICE

TO: [*Electronic filing*]
John Therriault, Clerk
Illinois Pollution Control Board
State of Illinois Center
100 W. Randolph Street, Suite 11-500
Chicago, Illinois 60601

[*Service by mail*]
Fred McCluskey
Midwest Generation, LLC
440 South LaSalle Street, Suite 3500
Chicago, Illinois 60605

[*Service by mail*]
Steve Santarelli
Illinois Department of Revenue
101 West Jefferson
P.O. Box 19033
Springfield, Illinois 62794

PLEASE TAKE NOTICE that I have today electronically filed with the Office of the Pollution Control Board the **APPEARANCE** and **RECOMMENDATION** of the Illinois Environmental Protection Agency, a paper copy of which is herewith served upon the applicant and a representative of the Illinois Department of Revenue.

Respectfully submitted by,

/s/ *Robb H. Layman*
Robb H. Layman
Assistant Counsel

Date: December 6, 2013

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276
Telephone: (217) 524-9137

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD
OF THE STATE OF ILLINOIS

MIDWEST GENERATION, LLC Low NOx Burner System with Separated Over-fire Air System for Waukegan Station, Unit No. 7	)	PCB 14- (Tax Certification - Air)
PROPERTY IDENTIFICATION NUMBER 08-15-200-006 or portion thereof	)	

APPEARANCE

I hereby file my Appearance in this proceeding on behalf of the Illinois Environmental Protection Agency.

Respectfully submitted by,

/s/ *Robb H. Layman*
Robb H. Layman
Assistant Counsel

Date: December 6, 2013

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RECOMMENDATION

NOW COMES the ILLINOIS ENVIRONMENTAL PROTECTION AGENCY ("Illinois EPA"), through its attorneys, and pursuant to 35 Ill. Adm. Code 125.204 of the ILLINOIS POLLUTION CONTROL BOARD'S ("Board") procedural regulations, files the Illinois EPA's Recommendation in the above-referenced request for tax certification of pollution control facilities. The Illinois EPA recommends **issuance** of a tax certification covering the subject matter of the request. In support thereof, the Illinois EPA states as follows:

1. On or about April 25, 2008, the Illinois EPA received an application and supporting information from MIDWEST GENERATION, LLC, ("Midwest Gen") concerning the proposed tax certification of certain air emission sources and/or equipment located at its Waukegan generating station in Lake County, Illinois. A copy of the application is attached hereto. **[Exhibit A]**. Following a belated discovery that the application had been misplaced, the Illinois EPA's undersigned attorney sought and obtained verbal confirmation from Midwest Gen concerning the continuing need for certification of the subject sources and/or equipment on December 6, 2013.

2. The applicant's principal business address is as follows:

Midwest Generation
440 South LaSalle Street, Suite 3500
Chicago, Illinois 60605

3. The facility address is as follows:

Midwest Generation
Waukegan Station
401 East Greenwood Avenue
Waukegan, Illinois 60087

4. The subject matter of this request consists of a Low Nitrous Oxide (NOx) Burner System with a Separated Over-fire Air Control System, which was constructed and installed by Midwest Gen on Unit No. 7 of the Waukegan Station. A low NOx burner system, as generally recognized in the field of air pollution control technology, is a type of process modification that offers enhanced abatement of NOx emissions while providing the basic functionality of conventional burners. An over-fire air system is a type of process modification that is not an inherent component of conventional boilers and provides a discrete, enhanced abatement of NOx emissions. As described in the application, the Low NOx Burner System for the affected boiler consists of the replacement of "all existing tilting nozzle tips in each wind box with redesigned tips and related dampers." *See,* Exhibit A, page 1 at Section D. The Over-fire Air System consisted of the upgrading of the "existing windbox partition plates" and the addition of "multi-staged... registers above the main firing zone." *Id.* The systems collectively regulate "the mixing of coal and air to limit oxygen availability during the initial stages of combustion" and, similarly, assure that "secondary air [mixes] with the products of initial combustion at a location near the flame boundary." *Id.* As a consequence, NOx formation during combustion is "inhibited" and the process modifications therefore act to prevent or reduce NOx emissions that would otherwise be emitted from the boiler. *Id.*

5. Section 11-10 of the Property Tax Code, 35 ILCS 200/11-10 (2002), defines "pollution control facilities" as:

> "any system, method, construction, device or appliance appurtenant thereto, or any portion of any building or equipment, that is designed, constructed, installed or operated for the primary purpose of: (a) eliminating, preventing, or reducing air

> or water pollution... or (b) treating, pretreating, modifying or disposing of any potential solid, liquid, gaseous pollutant which if released without treatment, pretreatment, modification or disposal might be harmful, detrimental or offensive to human, plant or animal life, or to property."

6. Pollution control facilities are entitled to preferential tax treatment, as provided by 35 ILCS 200/11-5 (2002).

7. Based on information in the application and the primary purpose of the Low NOx Burner System and the Separated Over-fire Air System to prevent or reduce air pollution, it is the Illinois EPA's engineering judgment that the systems and/or devices and related appurtenances may be considered as "pollution control facilities" in accordance with the statutory definition and consistent with the Board's regulations at 35 Ill. Adm. Code 125.200. **[Exhibit B].** In keeping with prior recommendations in similar matters, the Illinois EPA would expect any preferential tax treatment for the Low NOx Burner System, as determined by the Department of Revenue in separate proceedings, to address only the incremental costs associated with the system in relation to conventional burner systems.

8. Because the information in the application demonstrates that the Low NOx Burner System and the Separated Over-fire Air System satisfy the aforementioned statutory and regulatory criteria, the Illinois EPA recommends that the Board **issue** the applicant's requested tax certification.

Respectfully submitted by,

/s/ Robb H. Layman

Robb H. Layman
Assistant Counsel

DATED: December 6, 2013

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276
Telephone: (217) 524-9137

CERTIFICATE OF SERVICE

I hereby certify that on the 6th day of December, 2013, I electronically filed the following instruments entitled **NOTICE, APPEARANCE** and **RECOMMENDATION** with:

John Therriault, Clerk
Illinois Pollution Control Board
100 West Randolph Street
Suite 11-500
Chicago, Illinois 60601

and, further, that I did send a true and correct paper copy of the same foregoing instruments, by First Class Mail with postage thereon fully paid and deposited into the possession of the United States Postal Service, to:

Steve Santarelli
Illinois Department of Revenue
101 West Jefferson
P.O. Box 19033
Springfield, Illinois 62794

Fred McCluskey
Midwest Generation
440 South LaSalle Street, Suite 3500
Chicago, Illinois 60605

/s/ Robb H. Layman
Robb H. Layman
Assistant Counsel

APPLICATION CERTIFICATION (PROPERTY TAX TREATMENT)
POLLUTION CONTROL FACILITY

AIR [X] WATER [ ]

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
P. O. Box 19276, Springfield, IL 62794-9276

This. Agency is authorized to request this infonnation under 11linois RevisedSta"tues, 1979. Chapter, 120. Section 502a-5. Disclosure of this information is voluntary. However. failure to comply could prevent your application fronl being processed or colild result in denial of your application for certification.

FOR AGENCY USE

File No.	Date Received	Certification No.	Date

Sec. A APPLICANT

Company Name Midwest Generation, LLC – Waukegan Station (Unit 7) Low NOx Burner	
Person Authorized to Receive Certification Fred McCluskey	**Person to Contact for Additional Details** Jeff Bard
Street Address 440 South LaSalle Street Suite 3500	**Street Address** same
Municipality, State & Zip Code Chicago, IL 60605	**Municipality, State & Zip Code** same
Telephone Number 312-583-6000	**Telephone Number** same

RECEIVED
STATE OF ILLINOIS
APR 2 9 2008
Environmental Protection Agency
BUREAU OF AIR

Location of Facility **Quarter Section**	**Township** Waukegan	**Range**	**Municipality**	**Township**
Street Address 401 East Greenwood Ave. Waukegan, IL 60087			**County** Lake	**Book Number**
Property Identification Number 08-15-200-006			**Parcel Number**	

Sec. B MANUFACTURING OPERATIONS

Nature of Operations Conducted at the Above Location Waukegan Station Unit 7
Generation of Electricity from a coal fired power plant

Water Pollution Control Construction Permit No.	**Date Issued**	
NPDES Permit No.	**Date Issued**	**Expiration Date**
Air Pollution Control Construction Permit No. 01050038	**Date Issued** July 18, 2001	
Air Pollution Control Operating Permit No. 95090047	**Date Issued** September 19, 2002	

Sec. C MANUFACTURING PROCESS

Describe Unit Process
A steam electric boiler converts the chemical energy in the fuel coal into thermal energy that is used by a steam turbine. To achieve this two fundamental processes are necessary: combustion of the coal by mixing with oxygen, and the transfer of the thermal energy from the resulting combustion gases to the working fluids of water and steam. The device that converts mechanical energy into electrical energy is the generator. To handle the coal delivered to the plant a coal handling system that processes the coal is part of the operation for transfer and storage.

Materials Used in Process

Coal

Sec. D POLLUTION CONTROL FACILITY DESCRIPTION

Describe Pollution Abatement Control Facility - Low NOx Burners
A low NOx burner system with separated over-fire air has been installed. The low NOx burner system includes the replacement of all existing tilting nozzle tips in each wind box with redesigned tips and related dampers, and refurbishment of the existing windbox partition plates and adding multi-staged separated over-fire air registers above the main firing zone. Combustion NOx controls reduce NOx formation by staging or delaying the mixing of coal and air to limit oxygen availability during the initial stages of combustion thereby inhibiting NOx formation and directing secondary air to mix with the products of initial combustion at a location near the flame boundary thereby also inhibiting thermal NOx formation.

Exhibit A

Sec. E POLLUTION CONTROL FACILITY ACCOUNTING DATA

(1) Nature of Contaminants or Pollutants

	Material Retained, Captured or Recovered	
Contaminant or Pollutant	**DESCRIPTION**	**DISPOSAL OR USE**
Nitrogen Oxides (NOx)	Nitrogen Oxides (NOx)	NOx emissions are reduced

(2) Points of Waste Water Discharge

	Plans and Specifications Attached	**Yes**	**No** X
(3)	**Are contaminants (or residues) collected by the control facility?**	**Yes**	**No** X
(4)	**Date installation completed:** July 17, 2002 **Status of installation on date of application:** Complete		
(5)	**a. FAIR CASH VALUE IF CONSIDERED REAL PROPERTY:**		**$** 11,421,342
	b. NET SALVAGE VALUE IF CONSIDERED REAL PROPERTY:		**$**
	c. PRODUCTIVE GROSS ANNUAL INCOME OF CONTROL FACILITY:		**$**
	d. PRODUCTIVE NET ANNUAL INCOME OF CONTROL FACILITY:		**$**
	e. PERCENTAGE CONTROL FACILITY BEARS TO WHOLE FACILITY VALUE:		**%** 1.9%

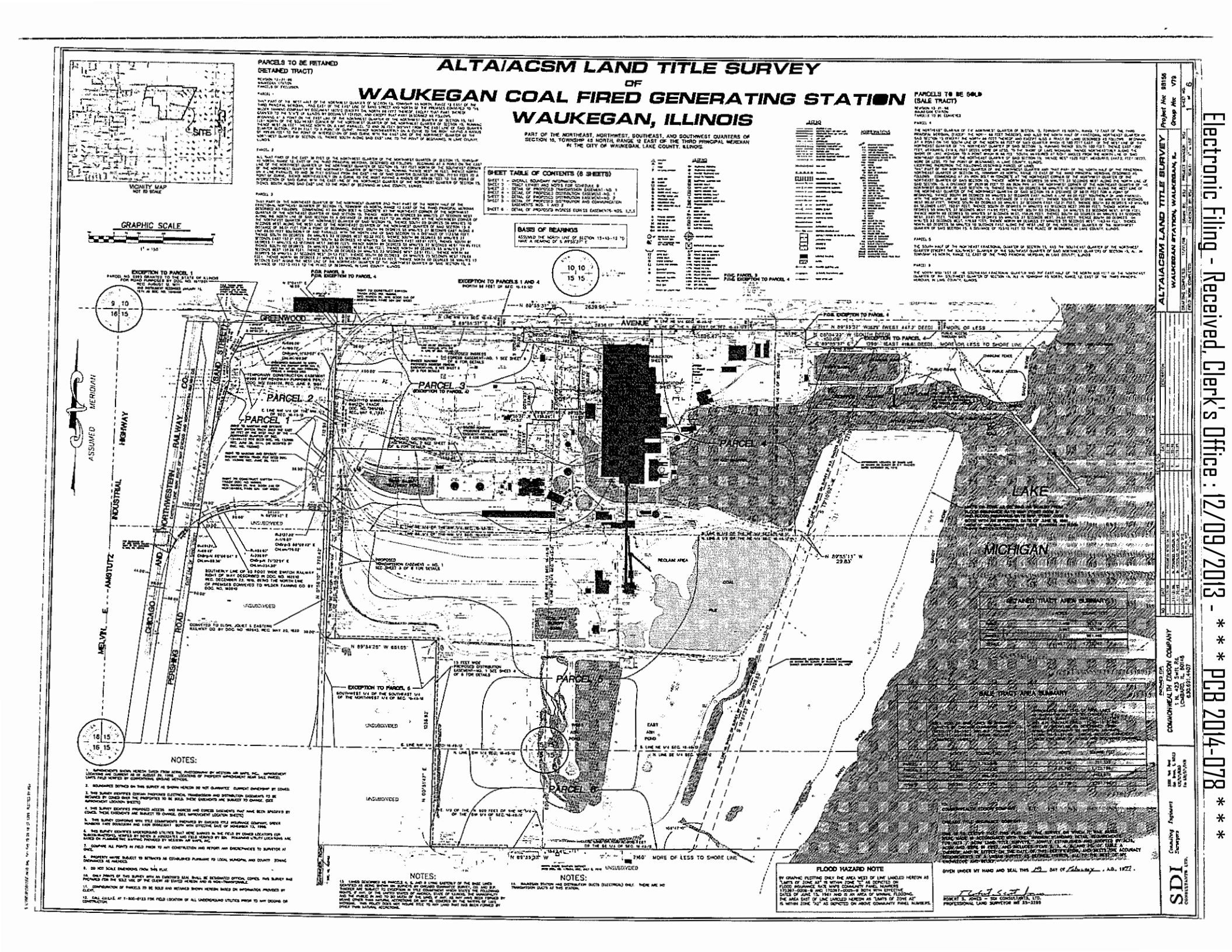
Sec. F SIGNATURE

The following information is submitted in accordance with the Illinois Property Tax code, as amended, and to the best of my knowledge, is true and correct. The facilities claimed herein are "pollution control facilities" as defined in Section 11-10 of the Illinois Property Tax Code.

Signature

Fred McCluskey
Vice President, Technical Services

Title



In-Furnace, Retrofit Ultra-Low NOx Control Technology for Tangential, Coal-Fired Boilers: The ABB C-E Services TFS 2000™R System

T. Buffa
D. Marti
United Illuminating

R. C. LaFlesh
ABB C-E Services, Inc.

ABB C-E Services, Inc.

ABSTRACT

United Illuminating and ABB C-E Services, Inc. report the first commercial retrofit installation and performance results from a TFS2000™R firing system. Pre-retrofit and post-retrofit field trials were conducted to evaluate the impact of the retrofit design on the boiler emissions and thermal performance. During testing, the retrofitted 390-MW_e utility boiler demonstrated NOx emissions on the order of 0.25 lb/10^6 Btu, while firing Eastern bituminous coal over the entire load range, without increase in unburned carbon (UBC). A potential minimum NOx emission level of 0.16 lb/10^6 Btu was achieved in parametric testing. The effects of the retrofit on boiler emissions, thermal performance and operating experience are reported.

INTRODUCTION

United Illuminating (UI) provides electricity to south-central Connecticut. In 1984, the electricity produced in the UI system came from an energy mix that was 94% fuel oil and 6% nuclear. To diversify its fuel base, in that year UI reconverted the Bridgeport Harbor Station Unit 3 (Figure 1) for coal firing. By 1985, the contribution of oil to UI's energy mix was reduced to 53%; nuclear was 9%, and coal had provided 37%. Continuing with its strategy of utilizing diverse fuels, UI shifted its energy mix to 1% natural gas, 5% hydro, 8% trash-to-energy, 17% oil, 35 % nuclear, and 34% coal by 1992.[1]

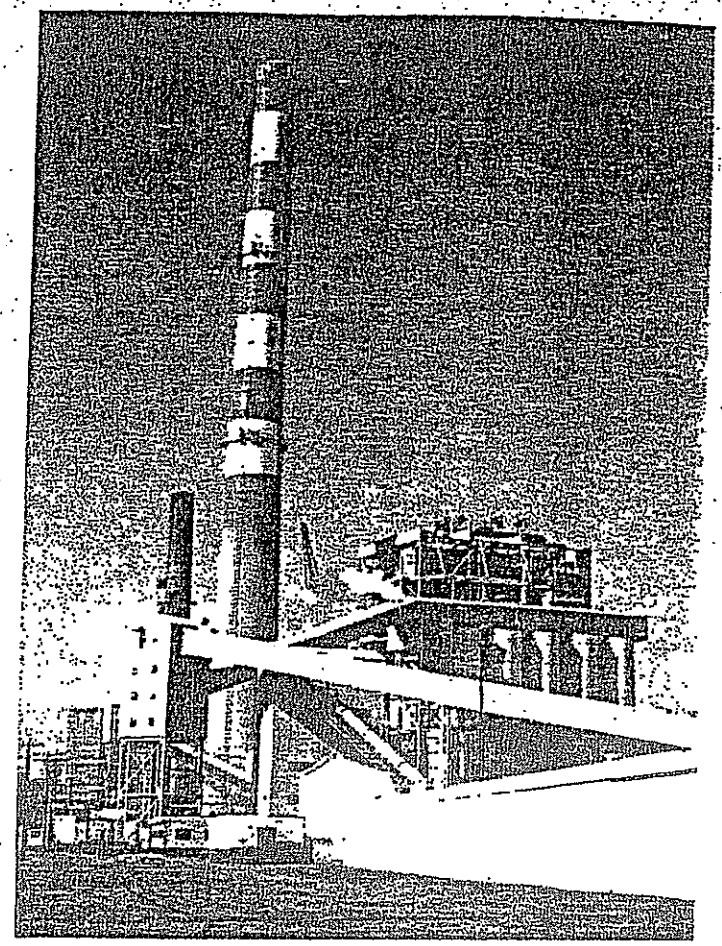


Figure 1: United Illuminating's Bridgeport Harbor Station

The city of Bridgeport is located in a "Severe" ozone nonattainment area under the 1990 Clean Air Act Amendments (CAAA) Title I. Bridgeport Harbor Station Unit 3 (BHS Unit 3) is a Phase II unit under CAAA Title IV. The State of Connecticut's Reasonably Achievable Control Technology (RACT) NOx limitation is 0.38 lb/10^6 Btu for tangential coal-fired boilers. With UI's fuel strategy in place, the utility decided to retrofit BHS Unit 3, its only coal-burning unit, with an aggressive low NOx firing system.

ABB C-E Services invited UI to participate in a research and development project in which BHS Unit 3 would serve as the first commercial field demonstration of TFS 2000™R technology. Similar technology had previously demonstrated ultra-low NOx emissions at the laboratory scale.[2]

UNIT DESCRIPTION

BHS Unit 3 is a Combustion Engineering, Inc., Controlled Circulation® steam generator with radiant reheat cycle and a pressurized furnace (Figure 2). It was designed in 1965 and commissioned in 1968. The steam generator is rated at 2,700,000 lb/hr primary steam flow at maximum continuous rating (MCR), with a corresponding reheat flow of 2,387,000 lb/hr. The MCR design superheat and reheat outlet steam temperatures are 1005 F. Operating pressure at the superheater outlet is 2629 psig.

Nominally rated at 390 MW_e, the unit was equipped with a Tilting Tangential Firing System for firing pulverized coal from five elevations and oil from four elevations. During the reconversion to coal firing in 1984, close-coupled overfire air was added. BHS Unit 3 operates with Eastern U.S. bituminous coals from sources in Kentucky. The coal composition is relatively uniform, with a low sulfur content and low slagging/fouling potential. Table 1 shows a typical coal analysis for BHS Unit 3.

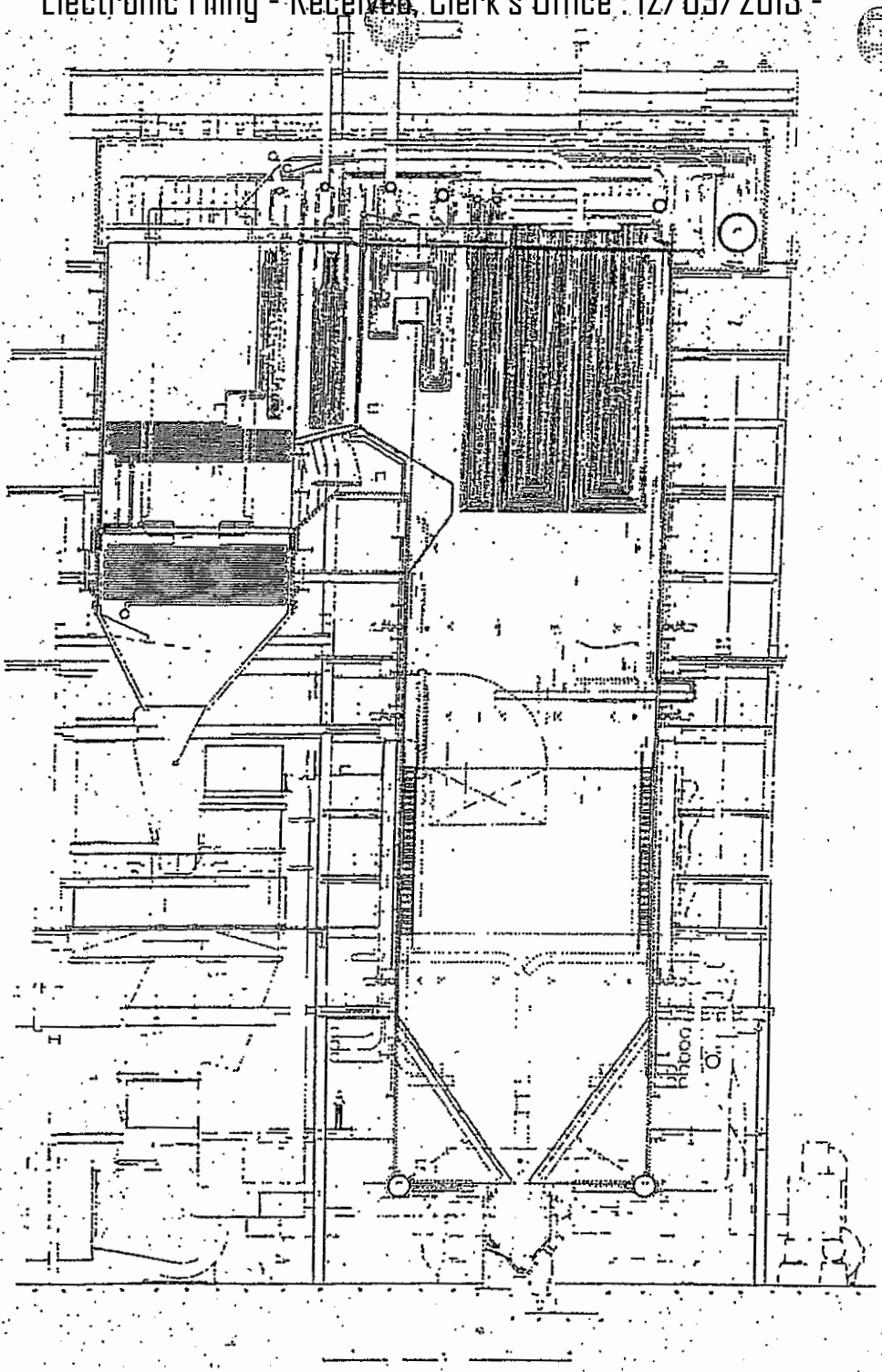


Figure 2: Brideport Harbor Station Unit 3, Pre-Retrofit Side Elevation

Moisture	5.4%
Volatile Matter	30.1%
Fixed Carbon	57.7%
Ash	6.8%
Nitrogen	1.4%
Sulfur	0.7%
FC/VM	1.92
HHV (Btu/lb)	13,400
Hardgrove Index	45

Table 1: Typical Coal Analysis

BHS Unit 3 is typically operated on automatic load dispatch, generating steam at MCR on weekdays and at control load or lower on nights and weekends. Pre-retrofit NOx emissions under normal operating conditions were in the range of 0.55-0.60 lb NOx/10^6 Btu. The unit had no history of significant slagging or fouling, and no history of pressure part failures related to the coal properties.

TFS 2000™R SYSTEM DESIGN

The TFS 2000™R System at BHS Unit 3 is an integrated retrofit design based on the successful laboratory development of Combustion Engineering, Inc.'s (ABB C-E) TFS 2000™ system for new boilers.[2] The challenge is to provide the most aggressive control of NOx emissions possible within the constraints of a fixed furnace geometry, without introducing any radical or negative departures from either design or operating practices. Previous research and development efforts suggested that the laboratory results for absolute NOx emissions, and trends for carbon monoxide and unburned carbon, were consistent with a utility boiler.[3] Therefore, the next step in the commercialization of the TFS 2000™R technology was a field demonstration on a large utility boiler.

The basic design philosophy of the TFS 2000™R firing system is based on the integration of four major principles:

1. Firing zone stoichiometry control
2. Pulverized coal fineness control
3. Initial combustion process control
4. Concentric firing

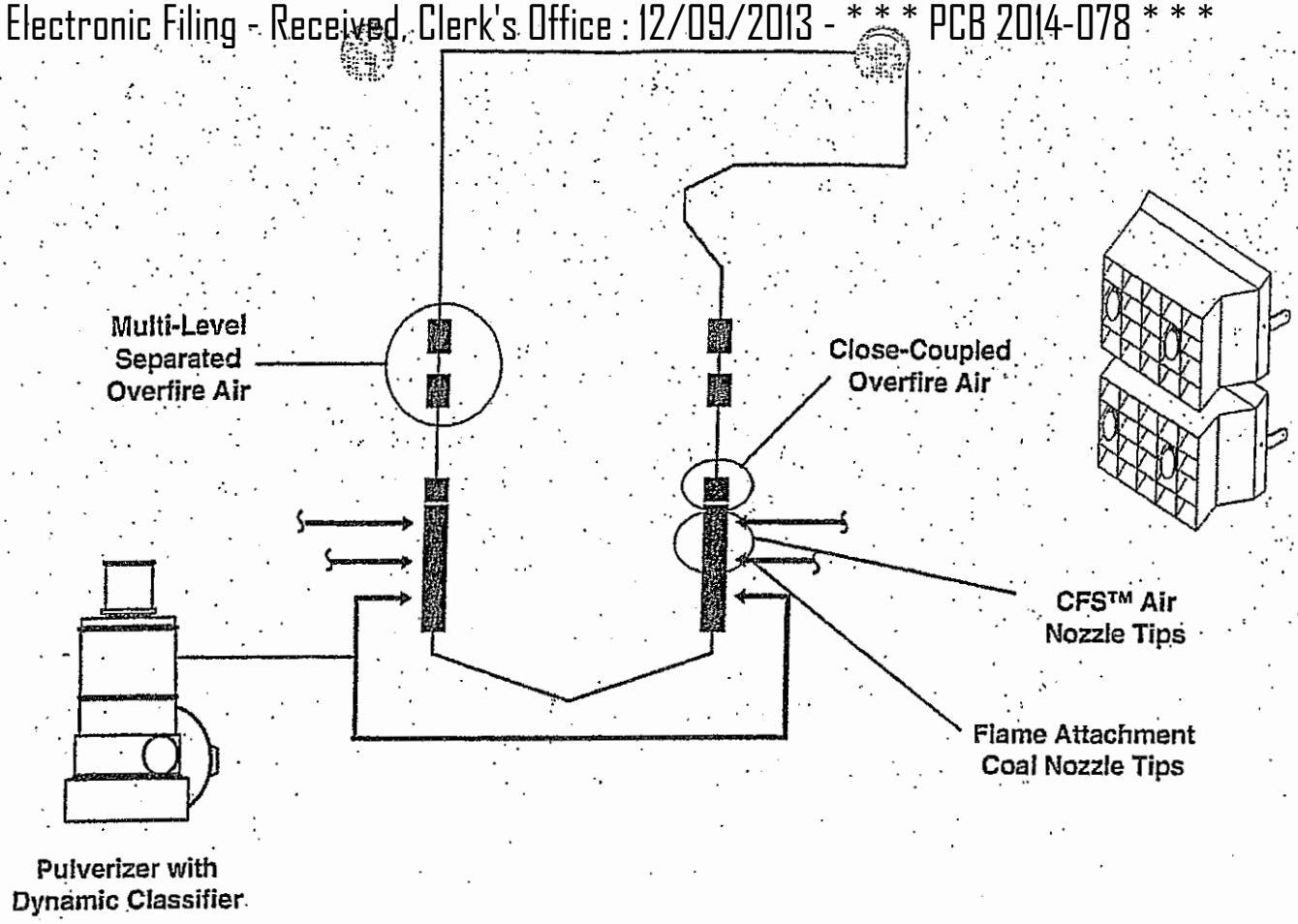


Figure 3: Schematic Diagram of a TFS 2000R Firing System

Laboratory testing has indicated that there is an optimum main firing zone stoichiometry for minimizing NOx emissions.[2] However, achieving this level of stoichiometry can result in high levels of CO and UBC. The TFS 2000™R system (Figure 3) controls the process of NOx formation and destruction in distinct regions of the furnace by "staging" the introduction of air through flame attachment coal nozzle tips and multiple levels of separated overfire air (SOFA) and close-coupled overfire air (CCOFA). The TFS 2000™R system thereby optimizes the entire stoichiometry history of the coal particles, to minimize NOx emissions.

Pulverized coal fineness is controlled by use of a Dynamic™ classifier. The rotating classifier vanes more effectively prevent larger coal particles from exiting the pulverizer, and this helps decrease the UBC levels in the flyash. Finer coal particles can also enhance fuel-bound nitrogen conversion and its subsequent reduction to molecular nitrogen under staged firing conditions by allowing rapid ignition near the coal nozzle tip.

Flame attachment coal nozzle tips are incorporated in the TFS 2000™R system design to provide early fuel devolatilization within an oxygen-deficient zone. With conventional firing systems, coal is devolatilized in an oxygen-rich environment, and the fuel nitrogen released can readily react with the available oxygen to form nitrogen oxide compounds. With the flame attachment coal nozzle tip, rapid coal devolatilization is accomplished by establishing a flame front near the exit of the tip. The coal nozzle tip design is based on existing flame characteristics, coal constituents, and fuel line transport conditions. Besides the NOx emissions control benefits, establishing coal ignition early in the combustion process improves flame stability and minimizes increases in unburned coal levels.

ABB's patented CFS™ concentric firing system air nozzle tips direct some of the secondary air in the main firing zone away from the fuel streams. Offsetting the air decreases the local firing zone stoichiometry during the initial combustion stages.

Concentric firing also creates an oxidizing environment near the furnace waterwalls in and above the main firing zone. This reduces ash deposition quantity and tenacity. Increased oxygen levels along the waterwalls also

decreases the potential for corrosion, especially with coals having high concentrations of sulfur, iron, or alkali metals.

The specific equipment components selected to achieve these elements of combustion will vary for different retrofit installations, depending on the design and maintenance condition of the installed equipment, and on the constructability constraints at the site.

TFS 2000™R SYSTEM IMPLEMENTATION

The retrofit equipment described below for the field demonstration of TFS 2000™R technology at BHS Unit 3 was installed in the Fall of 1993. The installation coincided with a scheduled maintenance outage for the turbine-generator. The outage duration was 8.5 weeks.

Windboxes

Because the existing main windboxes at BHS Unit 3 were in a deteriorated condition and the planned outage duration was short, the main windboxes were completely replaced with new, pre-assembled units. Each new main windbox (Figure 4) contains one bottom air compartment, four elevations of air/oil compartments with CFS™ air nozzle tips above and below the oil gun tips, two elevations of CCOFA compartments, and five elevations of coal compartments with flame attachment coal nozzle tips. New tilt mechanisms were provided at the compartments, re-using existing tilt drives. Secondary air flow to the windbox air registers is controlled by means of louver dampers equipped with self-lubricating damper bearing assemblies.

With ABB's flame attachment coal nozzle tips, the ignition point of the coal occurs closer to the nozzle tip than it does for conventional coal nozzle tips. The rapid fuel ignition produces a stable volatile matter flame and minimizes NOx production in the fuel-rich stream.

The CFS™ air nozzle tips supplied at BHS Unit 3 are equipped with manually-adjustable horizontal yaw mechanisms. The yaw adjustment is set so that a portion of the secondary air is directed away from the fuel streams toward an imaginary circle that is concentric with the main firing circle. The yaw angle is set during commissioning and is not changed during normal operation of the boiler.

The CCOFA elevation air registers direct a portion of the secondary air into the furnace at the top of the main windboxes. Each CCOFA compartment is equipped with ABB's patented horizontal yaw adjustment mechanism. The manual yaw adjustment enables each CCOFA air jet to be independently directed for effective mixing.

Two new SOFA registers were added above each of the new main windboxes. Each SOFA register contains three air compartments with adjustable horizontal yaw and vertical tilt mechanisms (Figure 5). During commissioning, the yaw angle is set to minimize carbon monoxide and UBC emissions. This is a manual adjustment that is not intended to be varied during operation.

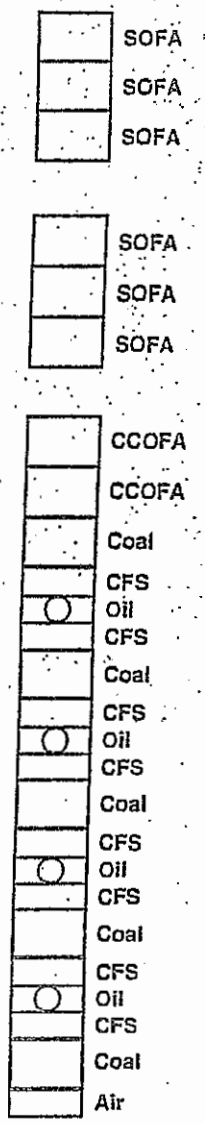


Figure 4: Schematic Diagram of TFS 2000R Windboxes at BHS Unit 3

To measure the SOFA air flow, an annular venturi (Figure 6) was installed in each SOFA air supply duct. ABB's patented annular venturi design requires only about two-thirds the length of a standard venturi and measures air flow with an accuracy of ±5 percent. It has a signal-to-noise ratio of approximately 10. Annular venturi are not required components for a TFS 2000™R system retrofit.

Pulverizer Modifications

Pulverizer modifications to implement TFS 2000™R technology are also site-specific, and depend greatly on the condition of the existing pulverizers, as well as the

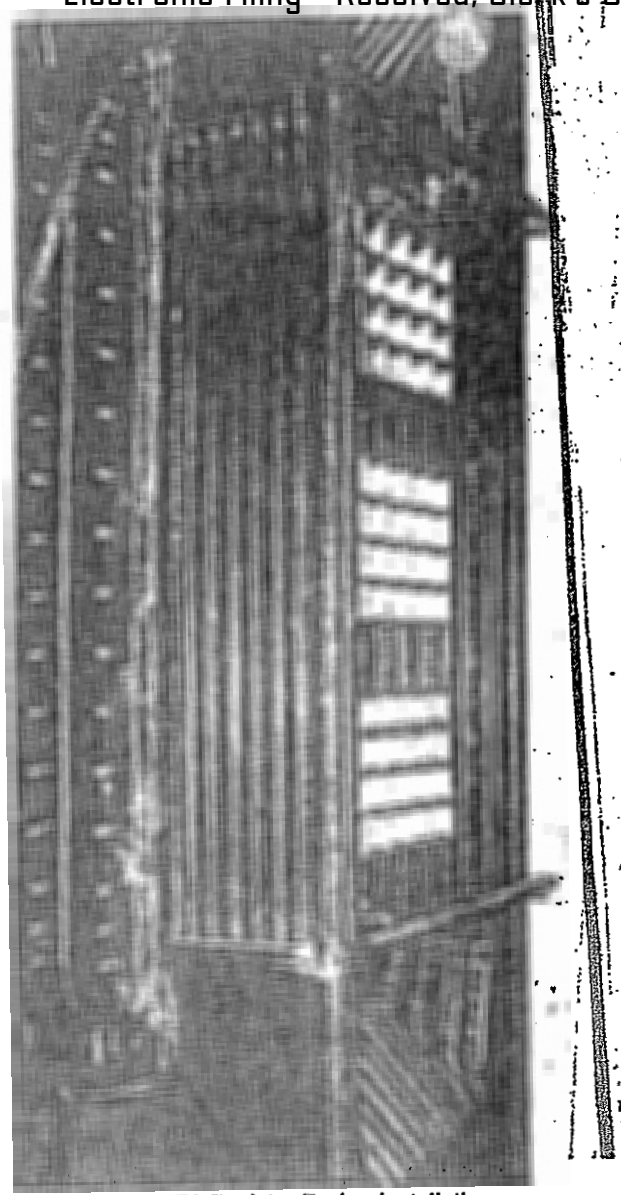


Figure 5: New SOFA Register During Installation

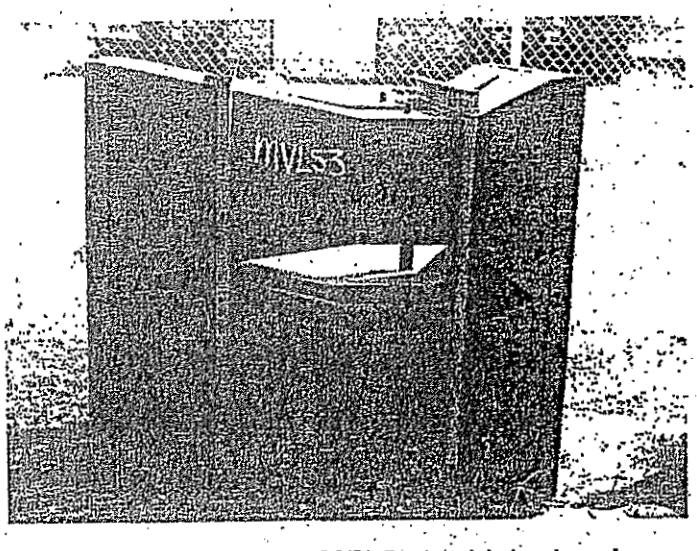


Figure 6: Annular Venturi for SOFA Ductwork in Laydown Area

coal to be fired after the retrofit. BHS Unit 3's five pulverizers were well-maintained and in good operating condition prior to the retrofit. The pulverizers were upgraded to permit operation at higher fineness levels without coal flow de-rating. The existing "spider" fan wheels were replaced by new high efficiency fans (HEF) utilizing the existing exhauster casings. In addition, the existing 600-Hp pulverizer motors were replaced with new 700-Hp motors. Figure 7 shows one of the new HEF wheels.

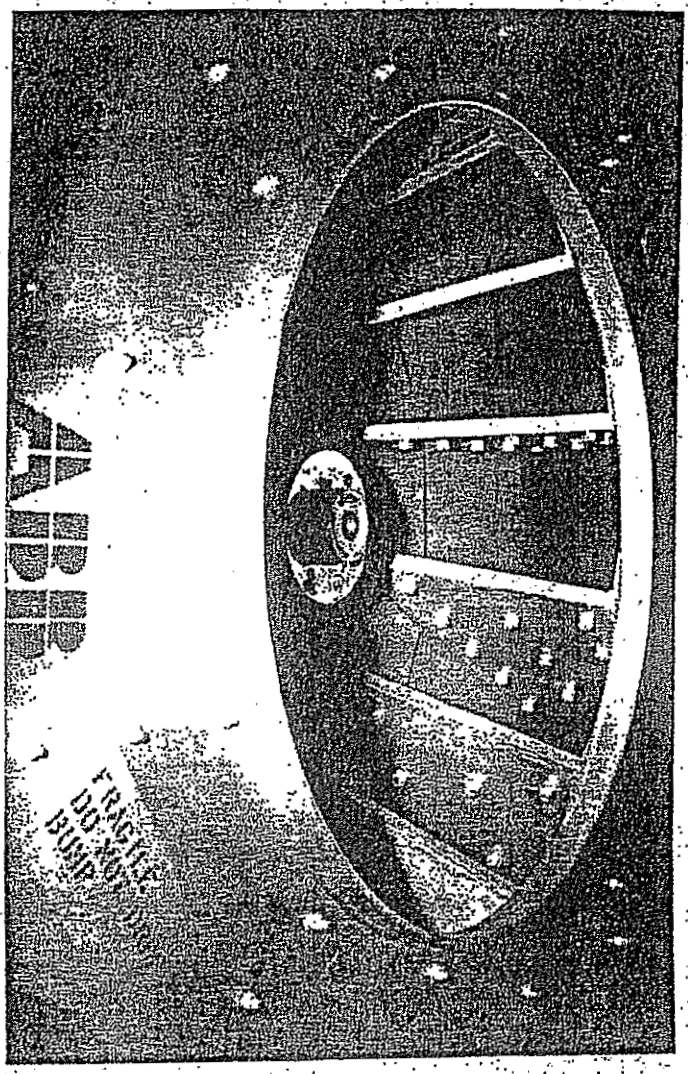


Figure 7: New HEF Wheel in the Existing Exhauster Casing

In each pulverizer, a new Dynamic™ classifier replaced the existing static classifier. The Dynamic™ classifier has a vaned rotor that is supported by two bearings. It is driven by a 40-Hp motor, and the speed of rotation is controlled through an ac variable-speed controller. Figure 8 is a photograph of one of the pulverizers during the installation of the Dynamic™ classifier. The Dynamic™ classifier effectively eliminates large coal particles (+50-mesh or +70-mesh) and minimizes the

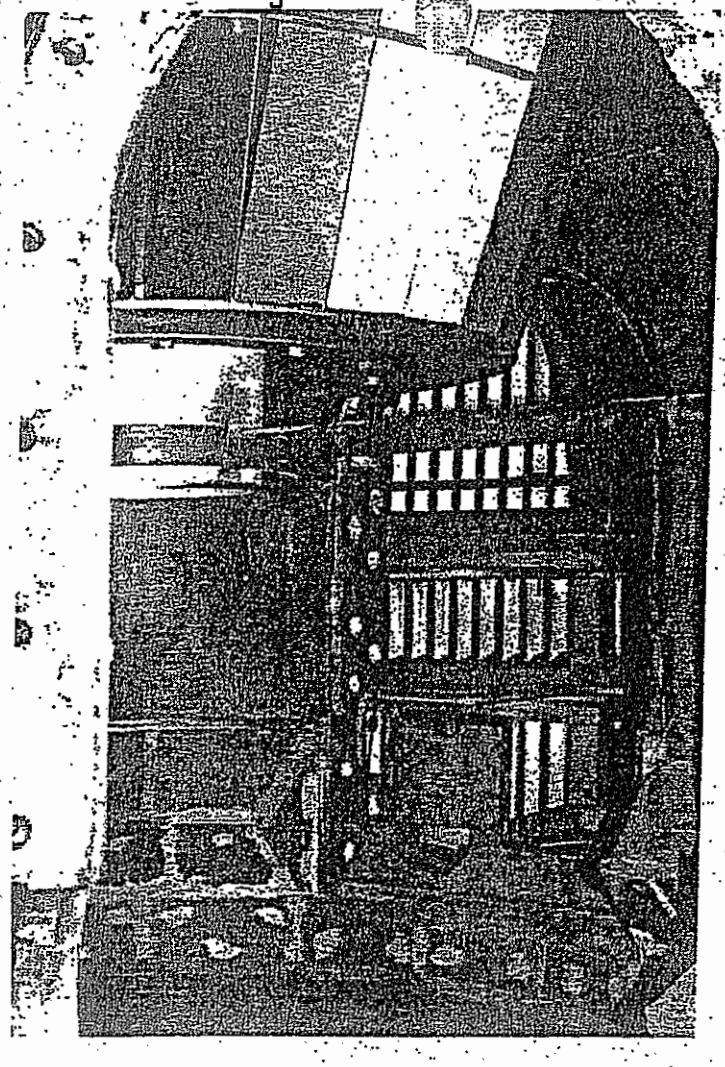


Figure 8: New Dynamic™ Classifier During Installation

fraction of +100-mesh coal particles. It allows extensive operational flexibility, and can be used to compensate for the effects of pulverizer wear, load changes, and changes in coal type or grindability.

Additional Work

Pressure part replacements requiring four main windbox tube panels and four SOFA tube panels accompanied the new windboxes and SOFA registers. Additional pressure part modifications were made at BHS Unit 3 to eliminate interferences with the SOFA register installation.

As part of the research and development project, 39 waterwall chordal thermocouples and 135 convective section thermocouples were installed to provide accurate and convenient measurements of the boiler's thermal performance under load. In addition, six waterwall test panels were installed to investigate industry concerns regarding long-term waterwall tube wastage under sub-stoichiometric firing conditions. These panels were fabricated of new waterwall tubing and were subjected to ultrasonic thickness measurement prior to installation. Tubing thickness will be regularly monitored during future maintenance outages. Figure 9 shows the approximate locations of this test equipment.

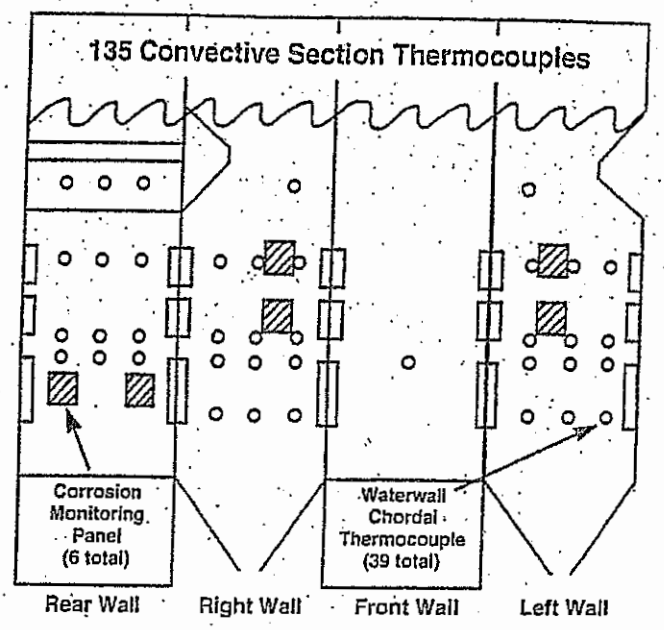


Figure 9: Locations of Test Thermocouples and Test Panels

Control system inputs/outputs and logic were added for operation of SOFA dampers and Dynamic™ classifiers, and to expand the operational flexibility of all windbox dampers. In addition, UI elected to perform additional back pass modifications, to upgrade the DCS control system and to add continuous stack emissions monitors and stack elevator during the outage. These modifications were not required for the new firing system.

TFS 2000™R SYSTEM PERFORMANCE EVALUATION

Pre-retrofit and post-retrofit field trials were conducted to evaluate the impact of the new design on the boiler emissions and thermal performance. The focus of the field trials was to quantify the impact of the new firing system over the full operating range of the boiler.

BOILER EMISSIONS PERFORMANCE

The boiler emissions performance was characterized through a series of parametric tests during which certain operational parameters were varied in a systematic fashion for several scenarios of boiler load, staged firing, and secondary air biasing.

NOx Emissions

All NOx measurements in this paper were determined via EPA Method 7E, using a chemiluminescent NOx

analyzer, and are reported in units of lb NOx/10^6 Btu. Figure 10 shows the relationship of the measured NOx emissions from BHS Unit 3 to the calculated stoichiometry at the top coal elevation for both the pre-retrofit and post-retrofit configurations of the boiler. All measurements were taken at MCR. The characteristic decrease in NOx emissions with decreasing stoichiometry is evident. Pre-retrofit NOx testing with the use of CCOFA showed NOx levels in the range of 0.46 - 0.58 lb NOx/10^6 Btu.

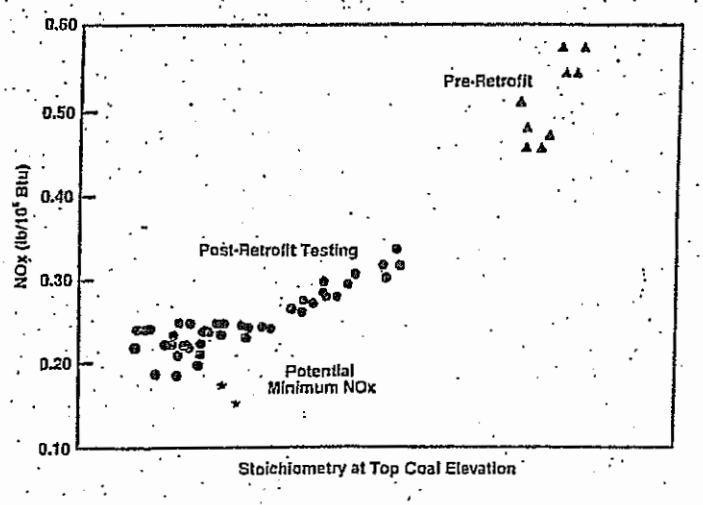


Figure 10: NOx Emissions vs. Stoichiometry at MCR

Sixty-six post-retrofit tests were conducted while varying the coal fineness and the degree of staging and mixing, along with a number of operating variables such as excess air. Post-retrofit NOx emissions as low as 0.20 lb NOx/10^6 Btu were achieved with *no increase in the UBC in the flyash.*

The two data points labeled "Potential Minimum NOx" (0.18 and 0.16 lb NOx/10^6 Btu) represent short-term (approximately 3 hours) test results. These results were achieved with carbon monoxide emissions less than 200 ppm and only a two-percentage point increase in UBC emissions over the pre-retrofit level. *It is significant that the potential minimum NOx results were achieved at a higher stoichiometry than many of the higher post-retrofit testing results, demonstrating that stoichiometry is not the only variable affecting NOx emissions.*

The post-retrofit test NOx emissions as a function of boiler load are shown in Figure 11. The secondary air dampers and tilts were controlled to operate the boiler with NOx emissions on the order of 0.25 lb NOx/10^6 Btu from MCR through control load (CL), to minimum load, with no increase in UBC in the flyash. Although it is typically expected that NOx levels will increase dramatically at low boiler load because of the required increase in excess air, at BHS Unit 3, the post-retrofit NOx emission at minimum load can be controlled to less than 0.30 lb/10^6 Btu.

Figure 12 compares the BHS Unit 3 post-retrofit testing for NOx emissions to other low NOx retrofit results for similar coals in tangentially-fired boilers. The pre-retrofit average NOx emissions of 0.62 lb/10^6 Btu for 14 other units firing Eastern bituminous coals is shown in the first (left) bar. ABB C-E Services' LNCFS™ firing systems were applied in these units.[4] As shown in Figure 12, LNCFS™ system field results reached a lower limit for NOx emissions at an average of 0.36 lb/10^6 Btu. The BHS Unit 3 field demonstration test results for NOx emissions are significantly lower.

Carbon Monoxide Emissions

All carbon monoxide (CO) measurements reported in this paper are given in units of parts per million (ppm) of

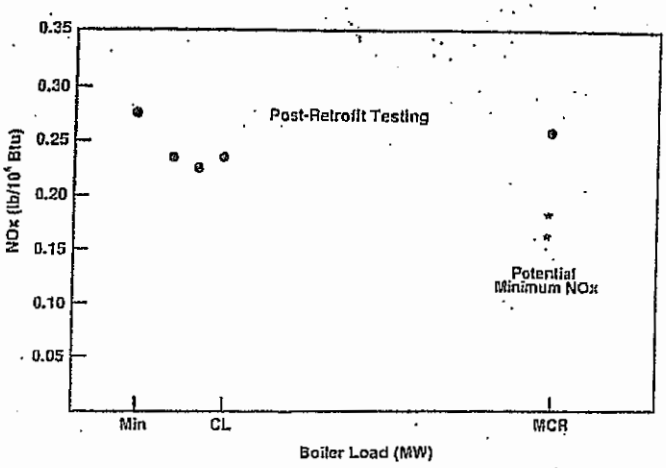


Figure 11: NOx Emissions vs. Boiler Load

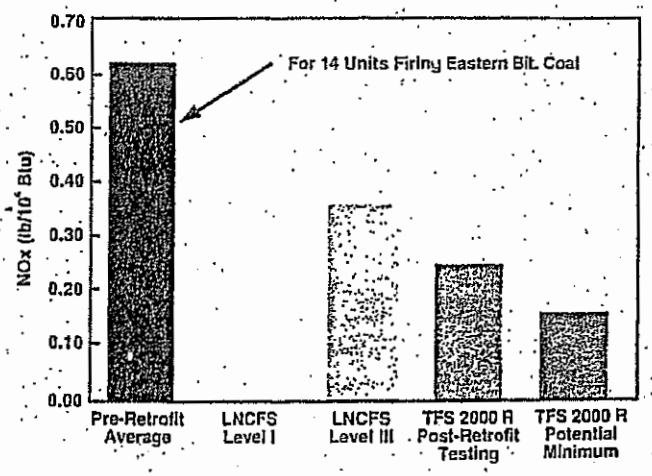


Figure 12: Comparison of ABB Retrofit Results for NOx Emissions

gas and are corrected to 3% oxygen in the flue gas. The test protocols used are in accordance with EPA Method 10. Pre-retrofit CO emissions were less than 50 ppm. During the post-retrofit testing the SOFA yaw angles were varied to demonstrate the variation of CO emissions with NOx. During the tests documented in Figure 10, at full load, CO levels of 44 ppm were obtained at NOx emissions of 0.34 lb/10^6 Btu; CO emissions of 22 ppm occurred with NOx emissions of 0.24 lb/10^6 Btu; and CO emissions of 178 ppm were found with NOx emissions of 0.16 lb/10^6 Btu.

Opacity

Opacity measurements were taken with the plant instrumentation. At BHS Unit 3, the regulated opacity limit is 20%. The pre-retrofit opacity averaged less than 10%. During the post-retrofit testing, the opacity remained less than 10% for most tests, and below the regulated limit under all test conditions. Isokinetic sampling of the flue gas entering the unit's electrostatic precipitator (ESP) confirmed that there was no significant change in the fly-ash (dust) loading entering the ESP. No significant change in the mass ratio of flyash-to-bottom ash was observed.

BOILER OPERATIONAL PERFORMANCE

During post-retrofit testing on the BHS Unit 3 boiler, multiple aspects of boiler operation were investigated to ensure that there were no adverse impacts on boiler operation related to the changes in the firing system.

Ash and Slag Deposition Patterns

A long-term change in the ash and slag deposition during operation was noted. Post-retrofit ash deposition has increased in the superheater sections closest to the furnace outlet, the superheater division panels and superheater platen assemblies (Figure 2). These ash deposits are friable and easily removed. No other significant changes in ash accumulation have been observed in the convective sections of the boiler. Slagging has decreased on about one-third of the furnace wall, in the areas near the CFS™ air elevations. Although the ash and slag deposition patterns have changed, they are controllable with the existing sootblowers and wall blowers on the boiler.

The boiler had no history of waterwall corrosion before the retrofit. After approximately ten months of post-retrofit operation, no evidence of accelerated waterwall wastage has been observed.

Coal Fineness

Calibration runs for the Dynamic™ classifier with the "B" pulverizer established the relationships among coal feed rate, fineness, and classifier rotation speed. Generally, a higher classifier rpm produces greater fineness, and rpm can be decreased as coal feed rates are decreased. At all coal feed rates, the coal fineness achievable with the Dynamic™ classifier is finer than with the static classifier, particularly in terms of decreasing or eliminating the largest +50 and +70-mesh particles. Coal particles in these size ranges have significant impact on UBC. Figure 13 compares the performance of the static classifier and the Dynamic™ classifier at BHS Unit 3 with five pulverizers, each in service at 55,000 lb coal/h.

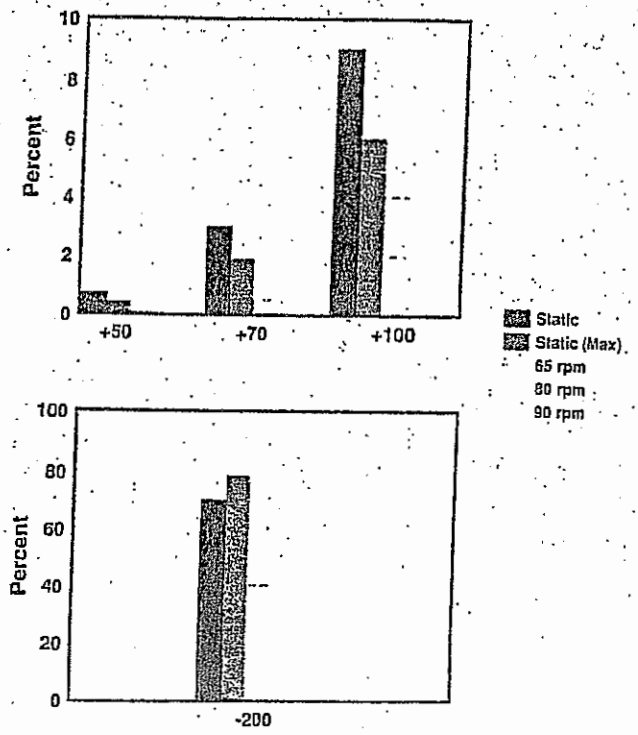


Figure 13: Comparison of Static and Dynamic Classifier Fineness Results

Pulverizer performance has met expectations, with the exception of a "rumble" condition that occurred during testing at high classifier rotation speeds. High fineness "rumble" can occur with either dynamic or static classifiers on a high-fineness setting. High fineness "rumble" is an instability, leading to vibrations, that is caused by an increase in recirculation of fine particles. At BHS Unit 3, the Dynamic™ classifier rotational speed is currently limited to avoid high fineness "rumble". A study is in progress at the ABB Power Plant Laboratories Pulverizer Development Facility in Windsor, Conn., to develop a methodology for predicting/preventing the onset of high fineness "rumble".[5]

Furnace Oxygen Imbalance

The oxygen concentration in the flue gas was measured at the economizer outlet in accordance with EPA Method 3A. Post-retrofit left/right oxygen imbalance is less than or equal to the pre-retrofit performance.

Boiler Efficiency

The installation of the TFS 2000™R firing system did not affect the boiler thermal efficiency (ASME Performance Test Code 4.1). Pre-retrofit and post-retrofit boiler efficiencies were calculated at MCR and at control load, and the efficiency remained at 91.4 - 91.7 percent, regardless of the NOx emissions level.

Steam Temperature/Flow Control

All post-retrofit operation of the boiler confirms that the superheater and reheater design outlet steam temperatures can be maintained at loads from MCR through control load. In addition, the superheater and reheater design pressures and mass flow rates are maintained at all loads from MCR through control load.

Steam temperature control is accomplished through the use of the adjustable tilts and the interstage desuperheaters. The windbox tilts continue to operate within their normal range.

At both the maximum and potential minimum NOx emissions levels, the post-retrofit reheater desuperheater spray water flows were about the same as the pre-retrofit levels. Thus, the implementation of TFS 2000™R technology does not adversely impact the unit's heat rate.

Element Steam Temperature Imbalance

Eight pre-retrofit tests and two post-retrofit tests were analyzed. Two of the pre-retrofit tests were for normal operation, three were for operation with the top secondary air dampers closed, and three were for operation with three tilt positions. One post-retrofit test was conducted with maximum SOFA and acceptable boiler operation, and the other was at the minimum NOx emission. The (low temperature) superheater rear pendant outlet – steam temperatures, (high temperature) superheater finishing pendant outlet temperatures, and the high temperature reheater outlet temperatures were measured and analyzed. As compared to the initial operation of the unit, firing oil, in 1968, there was no significant difference in the element steam temperature profiles caused by the TFS 2000™R system.

Maximum Local Heat Absorption Rates

The peak waterwall heat absorption rates calculated from readings with the chordal thermocouples installed in the furnace walls were well below the design values and confirm that the post-retrofit departure from nucleate boiling (DNB) margin for the boiler remains within ABB C-E design standards.

Vertical Heat Absorption Profile

The vertical heat absorption profile, as measured through the chordal waterwall thermocouples is similar under all post-retrofit operating conditions. There is a slight shift in the furnace vertical heat absorption profile towards the upper furnace under potential minimum NOx conditions. This shift did not adversely affect boiler waterwall circulation.

UBC AS A FUNCTION OF NOx EMISSIONS

Significant increases in UBC levels in the flyash have been documented for boilers retrofitted with earlier low NOx firing systems.[4] Pre-retrofit UBC levels at BHS Unit 3 were in the range of 5.8 - 8.0 percent carbon. For a tangentially-fired boiler with an Eastern bituminous coal, this range is about average.

The flyash samples for both the pre-retrofit and post-retrofit UBC results were obtained in accordance with EPA Method 17. Carbon content was determined directly, not by loss of ignition (LOI).

UBC levels for post-retrofit operation at BHS Unit 3 with three different fineness levels are given in Figure 14. For this comparison, boiler load was held constant at MCR. The trend of increasing UBC with decreasing NOx emissions is evident for the three post-retrofit data sets. The trends also illustrate that UBC control is dependent upon the particle size of the coal. NOx emissions as low as 0.20 lb/10^6 Btu were obtained with no increase above pre-retrofit levels of UBC in the flyash.

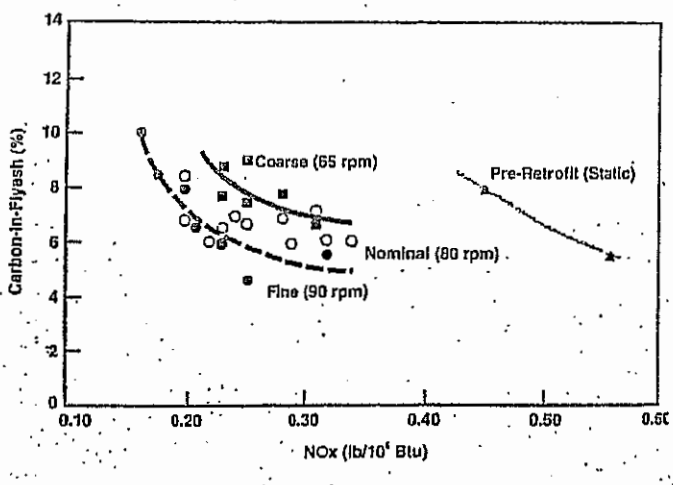


Figure 14: UBC in Flyash vs. NOx Emissions at MCR

COMMERCIAL OPERATING EXPERIENCE

The unit has been operating commercially, post-retrofit, firing coal for about ten months. The unit operates under load dispatch at MCR on weekdays from about 8:00 am to 11:00 pm. At night and on weekends, the unit load is decreased to as low as 140 MW. Operators report no significant operational problems, and no indication of accelerated waterwall wastage or corrosion has been observed.

CONCLUSIONS

United Illuminating and ABB C-E Services consider the retrofit of Bridgeport Harbor Station's Unit 3 to be a commercially and technically successful full-scale demonstration of TFS 2000™R technology. The boiler thermal performance and efficiency are unchanged from the pre-retrofit conditions. Although the slagging/fouling patterns have changed slightly from pre-retrofit, the existing sootblowers and wall blowers are capable of controlling them.

During testing, the boiler consistently demonstrated NOx emissions on the order of 0.25 lb/10^6 Btu over the entire load range, with no increase in unburned carbon in the flyash. The lowest NOx emissions measured for this boiler during post-retrofit parametric testing is 0.16 lb/10^6 Btu. The potential for long-term operation of the boiler at this level has not been thoroughly investigated. In approximately ten months of commercial operation, operation of the boiler with the TFS 2000™R technology has caused no significant adverse impact on boiler operation or availability.

ACKNOWLEDGEMENTS

The authors acknowledge and appreciate the efforts and expertise of all the individuals from United Illuminating and ABB who were involved in the success of this field demonstration project. The contributions of D. Gillespie, P. Olson, A. Cortiglio, T. Dorazio, W. Derech, V. Piras, and R. Collette are especially noted. Thanks also to R. Lewis, G. Strich, D. Choi, P. Stanwicks, T. Kelly, C. Boyle, B. Walsh, and C. Doherty for their valuable contributions.

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2. Marion, J.L., Towle, D.P., Kunkel, R.C, and LaFlesh, R.C, *Development of ABB C-E's Tangential Firing System 2000 (TFS 2000™ System)*, EPRI/EPA 1993 Joint Symposium on Stationary Combustion NOx Control, reprinted as TIS 8603, 1993.

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4. Hart, D., *Operating Results from ABB C-E Services' LNCFS™ Low NOx Concentric Firing System Retrofit Installations* – 1994 Update, TIS 8620.

5. *State-of-the-Art Pulverizer Development Facility*, **Power Perspectives**, ABB, September, 1994.

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

P.O. BOX 19506, SPRINGFIELD, ILLINOIS 62794-9506

THOMAS V. SKINNER, DIRECTOR

217/782-2113

CONSTRUCTION PERMIT

PERMITTEE

Midwest Generation EME, LLC
Attn: Bob Duey, Plant Manager
401 East Greenwood Avenue
Waukegan, Illinois 60087

Application No.: 01050038 I.D. No.: 097190AAC
Applicant's Designation: WAU7NOXLNB Date Received: May 14, 2001
Subject: Low NO_x Burner Installation, Unit 7
Date Issued: July 18, 2001
Location: 401 East Greenwood Avenue, Waukegan

Permit is hereby granted to the above-designated Permittee to CONSTRUCT emission source(s) and/or air pollution control equipment consisting of a low nitrogen oxides (NO_x) burner system for Boiler 7, at Waukegan electrical generating station as described in the above-referenced application. This Permit is subject to standard conditions attached hereto and the following special condition(s):

1a. This permit is issued based on installation of low NO_x burner being a pollution control project whose principle purpose is to reduce emissions of nitrogen oxides (NO_x).

b. This permit does not relax or otherwise revise any requirements and conditions that apply to the operation of the existing steam generating unit (Boiler 7), including applicable monitoring, testing, recordkeeping, and reporting requirements pursuant to federal Acid Rain Program.

2a. The Permittee shall submit a semi-annual report describing the project status until such time as the Permittee notifies the Illinois EPA that the project has successfully demonstrated reliable operation. This report shall be sent to the following addresses:

Illinois Environmental Protection Agency
Division of Air Pollution Control - Regional Office
9511 West Harrison
Des Plaines, Illinois 60016

Telephone: 847/294-4000 Facsimile: 847/294-4018

Illinois Environmental Protection Agency
Division of Air Pollution Control
Compliance Section (#40)
P.O. Box 19276
Springfield, Illinois 67294-9276

Telephone: 217/782-5811 Facsimile: 217/524-4710

b. The Permittee shall notify the Illinois EPA when the low-NO_x burner system begins initial operation.

c. Within one year of the initial startup of the unit with low-NO_x burner system, the Permittee shall submit a performance report to the Illinois EPA discussing the effects on NO_x emissions from the steam generating unit and any effects on emissions of other pollutants, such as carbon monoxide and particulate matter, and any effects on boiler efficiency or capacity.

d. The boiler may be operated with the low-NO_x burner system, pursuant to this construction permit until either the existing operating permit is reissued to address the low NO_x burner system or a CAAPP permit is issued for the source.

3a. The Illinois EPA has determined that this project, as described in the application, will not constitute a modification of Boiler 7 under the federal New Source Performance Standards, 40 CFR 60 because the project has the primary function of reducing air pollutants and therefore is not considered a modification pursuant to 40 CFR 60.14(e)(5).

b. The Illinois EPA has determined that this project, as described in the application, will not constitute a modification for Boiler 7 under the federal Prevention of Significant Deterioration of Air Quality (PSD) rules because it is a pollution control project and therefore is not considered a modification pursuant to 40 CFR 52.21(b)(2)(iii)(h) and (b)(32).

Please note that additional rules addressing NO_x emissions from this boiler may be adopted in the near future in response to USEPA=s so called ANO_x SIP call@ and the development of Illinois= plan for attainment of the ozone air quality standard in the Chicago and Metro-East ozone nonattainment areas.

If you have any questions concerning this permit, please call Mohamed Anane at 217/782-2113.

Donald E. Sutton

Donald E. Sutton, P.E.
Manager, Permit Section
Division of Air Pollution Control

DES:MA:psj

cc: Region 1

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

1021 NORTH GRAND AVENUE EAST, P.O. BOX 19506, SPRINGFIELD, ILLINOIS 62794-9506 – (217) 782-2113

ROD R. BLAGOJEVICH, GOVERNOR DOUGLAS P. SCOTT, DIRECTOR

Memorandum

Technical Recommendation for Tax Certification Approval

Date: December 29, 2008

To: Robb Layman

From: Ed Bakowski

Subject: Midwest Generation, LLC. TC 08-04-25D

This Agency received a request on April 25, 2008 from Midwest Generation, LLC. for an Illinois EPA recommendation regarding tax certification of air pollution control facilities pursuant to 35 Ill. Adm. Code 125.204. I offer the following recommendation.

The air pollution control facilities in this request include the following:

Low NOX Burner system with Separated Over-Fire Air System for Boiler 7 which reduces NOX formation by delaying the mixing of coal and air to limit oxygen availability during initial stages of combustion thereby reducing NOX emissions. Because the primary purpose of this system is to reduce or eliminate air pollution, it is certified as a pollution control facility.

This facility is located at 401 East Greenwood Avenue, Waukegan, Lake County
The property identification number is 08-15-200-006

Based on the information included in this submittal, it is my engineering Judgement that the proposed facility may be considered "Pollution Control Facilities" under 35 IAC 125.200(a), with the primary purpose of eliminating, preventing, or reducing air pollution, or as otherwise provided in this section, and therefore eligible for tax certification from the Illinois Pollution Control Board. Therefore, it is my recommendation that the Board issue the requested tax Certification for this facility.

Exhibit B