RETROFIT OF LOW NO_x COAL BURNERS TO TAIWAN POWER COMPANY LINKOU UNIT 1

by

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Presented at the
Power Generation '92 Conference
Orlando, Florida
November 17-19, 1992

RST-106

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ABSTRACT

Riley Stoker has been designing integrated low NO, combustion systems to ***maximize*** *NOz reduction capabilities while maintaining satisfactory operating performance. Taiwan Power is a case study in the application of this philosophy.*

Taiwan Power Linkou Unit 1 is a 300 MW pulverized coal wall fired unit where Riley's integrated approach to low NOx and unit performance was successfully applied. ***The application*** *of this philosophy is of particular importance with today's Clean Air Act Amendments* ***needed*** *for low NO ,, (< .5 lb/10^6 Btu) while maintaining unit operating* ***performance. Boiler efficiency, steam*** *temperature, and LOI were all evaluated in this retrofit project.*

Unit windbox flow modeling and comprehensive pre-modification ***testing*** *was* ***initially conducted to establish unit baseline*** *operation and to aid in the design of a successful low NOx retrofit system.*

This paper will discuss the results of this project while comparing the pre retrofit to post retrofit testing and how the knowledge learned is being applied to today's low M_x retrofit systems.

Also discussed will be the results of testing the latest CCV burner in Riley Stoker's Coal ***Burner*** *Test Facility. The results are of great importance with the lower NOX emissions capabilities while operating in an unstaged firing condition. The CCV burner's satisfactory* ***performance*** *over a wide range of fuel properties is discussed.*

INTRODUCTION

In May, 1991, Riley Stoker Corporation (RSC) was awarded a contract by Taiwan Power Company (TPC) to furnish engineering, material and to supervise erection for a new low NO_x combustion system for retrofit to Unit 1 at the Linkou Generating Station. Unit 1 is a 300 mw coal fired utility boiler originally designed and built by RSC in 1965. It is located on the northwest coast of the island of Taiwan in the Republic of China. The contract was in response to a major effort by the government of Taiwan to reduce NO_x emissions from several stationary sources throughout the Taiwan Power System.

The objective of the combustion modification project was to reduce NO_x emissions to 0.5 lb/10^6 Btu with future capability for 0.4 lb/10^6 Btu by retrofitting with state-of-the art Riley low NO_x combustion system technology. Emissions data collected in February, 1988 by the Industrial Technology Research Institute (ITRI), Hsinchu, Taiwan indicated that the NO_x emissions produced by Linkou Unit 1 at full load was averaging 1.04 lb/10^6 Btu. A 52% reduction in NO_x would be required to comply with the 0.5 lb/10^6 Btu NO_x requirement while a 61% reduction would be necessary for 0.4 lb/10^6 Btu. Consistent with these emission limits was the requirement for boiler operating performance to remain unchanged. This specifically included steam temperature, economizer exit gas temperature, excess air, boiler efficiency and the amount of unburned carbon in the fly ash.

The low NO_x combustion system retrofit included the following primary equipment:

- New low NO_x coal burners
- New advanced overfire air (OFA) system
- New boundary air system
- New burner and OFA controls

The project also included performing a 3-dimensional air flow model study of the windbox and OFA system to ensure balanced air flows to all the ports and burners.

Engineering efforts began in May, 1991. Pre-retrofit baseline testing for emissions and full boiler performance was conducted in July, 1991. Material was delivered in March, 1992 and the equipment was installed in March, April and May, 1992. Post retrofit optimization and acceptance testing was then conducted in July and August, 1992. A significant portion of the three (3) month boiler outage was for turbine maintenance and not for the low NO_x retrofit. Typically, a low NO_x retrofit of this magnitude would take six (6) weeks for installation. This paper will present the results of this project.

Recent design improvements to the Riley low NO_x Controlled Combustion Venturi (CCV) burner were evaluated last spring in Riley's Coal Burner Test Facility (CBTF) to increase our NO_x reduction capabilities without the need for OFA. A 25-30% greater NO_x reduction from previous NO_x reduction capability was obtained with satisfactory performance over a wide range of bituminous coal properties. Highlights of these test results are discussed.

UNIT DESCRIPTION

Linkou Unit 1 of Taiwan Power Company is a 300 MW coal fired utility boiler, originally constructed by Riley Stoker in 1965. The steam generator produces steam at 2,100,000 lb/hr, 1008°F/1008°F superheat and reheat temperature and 2525 psig operating pressure. The furnace dimensions are 46' W x 36' D. **Figure 1** shows a drawing of the original boiler installation. Pulverized coal is supplied by three (3) double ended ball tube mills which feed eighteen (18) burners arranged in three (3) rows of six (6) burners per row. The burners are also equipped with #6 steam atomized oil guns for full load capability and #2 oil ignitors. Linkou Unit 1 burns an eastern bituminous coal from Tennessee and bituminous coal from Australia.

LOW NO_x RETROFIT WORK SCOPE

Figure 2 shows a drawing of the complete low NO_x combustion system retrofit which included burners, OFA and boundary air. The following describes the primary equipment supplied and work performed.

Low NO_x Burners

Eighteen (18) new low NO_x CCV™ burners were installed on the front wall. The CCV™ burner, shown in **Figure 3**, is a single register swirl stabilized low NO_x pulverized coal burner which Riley Stoker first developed in the early 1980s (1).

The key element of the burner design is the patented (U.S. Patent No. 4,479,442) Venturi coal nozzle and low swirl coal spreader located in the center of the burner. NO_x control is achieved through this design. The Venturi nozzle concentrates the fuel and air in the center of the coal nozzle creating a very fuel rich mixture. As this mixture passes over the coal spreader, the blades divide the coal stream into four (4) distinct streams which then enter the furnace in a gradual helical pattern producing very gradual mixing of the coal and secondary air. Secondary air is introduced to the furnace through the air register, supported off the burner front plate, and subsequently through the burner barrel. Devolatilization of the coal in the fuel rich mixture occurs at the burner exit in an oxygen lean primary combustion zone, resulting in lower fuel NO_x conversion. Peak flame temperature is also reduced, thus suppressing the thermal NO_x formation.

The air register/shroud assembly provides independent control of swirl and secondary air flow. The swirl is controlled by a multiple bladed register assembly using an externally mounted register drive. This manually adjusted register drive is set during start-up. A movable air shroud surrounding the register assembly controls relative burner air flow. The burner is equipped with a pitot tube for measuring air flow for balancing secondary air burner to burner. The register and secondary air barrel are connected by a metal expansion joint to allow for relative movement caused by varying boiler and windbox expansion rates. Control of secondary air flow to each burner is done by moving the shroud. Relative air flow measurement to each burner is by the specially designed pitot tube and read from a locally mounted magnahelic pressure gage.

The shrouds are used to automatically control a pre-selected windbox pressure throughout the boiler load range. By partially closing the shrouds, this windbox pressure will increase to the level necessary for proper OFA flow rates, penetration velocity and good burner air distribution. A typical windbox pressure control range may vary from 4" at full 100% load to 1.5" at

50% load. Maintaining a constant windbox pressure throughout the load range is not necessary. No additional ducting or dampers are required for this function.

In most cases the CCV™ burner alone has been capable of reducing NO_x by 30-50%. When combined with an OFA system, the reduction amounts increase to 50-70% from uncontrolled pre-NSPS levels.

This level of NO_x reduction has been achieved utilizing the Riley CCV™ burner equipped with only one (1) secondary air register which results in a mechanically simple design. Several years ago during the early development stages of the CCV burner, Riley evaluated and tested dual register designs. We found no advantage in using dual registers for the NO_x emission levels being required. The fact that the Riley design does not utilize "core air" in the center of the burner may contribute to this capability.

Overfire Air System

A total of sixteen (16) overfire air ports were installed on Linkou Unit 1: eight (8) ports on the front wall and four (4) ports on each sidewall. Typically, our normal practice is to install OFA ports are the firing wall only. However, in this application, they were also installed along the sidewalls since we felt the residence time available for burnout from the OFA port elevation to the furnace exit was relatively short. From flow model studies performed by Riley Research for EPRI in the mid 1980s (4), we learned that this type of arrangement produces better mixing in the same time duration than only having front wall OFA ports installed. Ideally, the best arrangement is with ports on all four (4) walls. The ports were also divided into 1/3 and 2/3 sections with automatic flow control dampers in order to maintain the proper OFA penetration throughout the boiler load range. In other words, the 1/3 and 2/3 dampers were programmed to automatically open and close at various load points to ensure the proper amount of OFA and penetration velocity is maintained throughout the load range.

On the front wall, one (1) OFA port was located above each burner column while two (2) wing ports were located between the last OFA port and both side waterwalls. The purpose for the wing OFA ports, based on our EPRI studies, was to produce good mixing between the overfire air and furnace gases travelling upward adjacent to the sidewalls. Swirling OFA was evaluated during the EPRI testing which was found to enhance some mixing near the burner wall. However, swirl did not produce added benefits when wing OFA ports are utilized. Riley Stoker, therefore, does not incorporate swirling OFA in the design of OFA systems.

The OFA ports for Linkou Unit 1 were all fed by a separate header system which was fed by ducts connecting back to the hot air ducts originally feeding the burners on both sidewalls. These hot air ducts were partitioned to divert 25% of the total combustion air to the OFA ports. The total OFA flow quantity was measured using hot wire anemometers permanently installed in these partitioned duct sections. As will be discussed later, the optimum location was selected based on results of the flow model study performed as part of this retrofit project.

Boundary Air System

Boundary air was introduced along each sidewall low in the furnace to mitigate any tube corrosion that might occur as a result of operating the burner zone sub-stoichiometrically. A small percentage of total combustion air was introduced at low velocity to provide an oxidizing layer along each sidewall. Openings in the waterwall were created by removing the 1/2" membrane between the tubes across the full depth of the unit.

As shown in Figure 2, two circular ducts, with manual flow control dampers, connected the hot air duct with a small header enclosure built around the waterwall openings on both sides of the unit.

Burner and OFA Controls

Each CCV burner shroud was equipped with a modulating type linear actuator. The burner shrouds were modulated as necessary to automatically control windbox to furnace ΔP to follow a predetermined boiler load based set point. The set points ranged from 4"wg at full load to 1.5"wg at 50% boiler load.

Overriding this automatic control was the ability to manually position the burner shrouds to various "full open" positions in order to balance the excess air side to side through the unit. This was quantified by measuring excess O_2 at the economizer outlet using nine (9) point sampling grids installed in both left and right outlet ducts.

As discussed later, this capability proved to be extremely beneficial during optimization testing particularly since the unit was experiencing a tremendous O_2 imbalance following the low NO_x retrofit due to a dirty air heater on one side of the unit. The "full open" shroud positions were biased to different amounts on a "per column" basis across the burner front.

Each OFA port was equipped with two (2) sections (1/3 and 2/3 area split) and individual control dampers in each section. The dampers were connected together and operated through common jackshafts by low speed electric actuators. All the 1/3 and 2/3 ports were opened or closed simultaneously following commands from boiler load (steam flow) as follows:

<50% load	all OFA ports closed
50%-70% load	1/3 OFA ports open
70%-80% load	1/3 closed, 2/3 open
80%-100% load	1/3 & 2/3 ports full open

These load points were established during characterization and optimization testing following the boiler retrofit.

Flow Model Study

In the early design phase of this project, a 1/12th scale plexiglas flow model was constructed and tested at Riley's R&D facility in Worcester, Massachusetts. The purpose was to evaluate the air distribution to all the burners, OFA ports and boundary air system and to develop internal vaning or modifications as necessary to ensure acceptable air flow distribution (± 10%). The model incorporated the complete combustion air system from the outlet of both air heaters, through all the ductwork, OFA ports, burners and windbox and boundary air ducts to the furnace walls.

Extensive testing was first conducted to properly design and locate the partition plate in the hot air duct to effectively divert, at minimal draft loss, approximately 25% of the total combustion air to the OFA system and the remaining 75% to the low NO_x burners. Testing efforts then focused on establishing nearly uniform air distribution to all the burners, OFA ports and the boundary air system. The model flow evaluation used normalized velocity distribution at several different test locations, air temperature and static pressure measurements. Yarn tufts tied to the tip of a rod provided visual flow direction indication.

Results of this testing showed the air distribution to all the burners and OFA ports was within $\pm$ 10% of the average flow without the need for internal vaning. Results also indicated no adverse impact of pressure drop on the existing equipment. The pressure drop for the complete low NO_x system was projected from this testing to be 3.7" wg as compared to 3.9" wg measured at Linkou Unit 1 during baseline testing prior to the retrofit.

TEST RESULTS

Two (2) baseline tests were performed on Linkou Unit 1 prior to the low NO_x retrofit to determine the uncontrolled emission levels and to quantify boiler performance. Data was first recorded in February, 1988 when Taiwan Power Company contracted with ITRI to measure emissions in all of their utility boilers. The NO_x level was 1.04 lb/10^6 Btu. Subsequent testing by the same emissions testing firm in July, 1991 just prior to the retrofit indicated the uncontrolled NO_x level was lower at 0.9 lb/10^6 Btu. However, as indicated by high CO emissions poor carbon burnout and poor coal fineness, the lower NO_x level measured last year was most likely due to simply poor combustion performance and not indicative of good operation.

Post retrofit testing was then performed last August, 1992 to evaluate performance of the new low NO_x combustion system. Results are summarized in **Table 1.** The NO_x emissions decreased from 1.04 to an average 0.38 lb/10^6 Btu for a 63% reduction when OFA was fully open. The boiler load tested at was 93% of MCR conditions because of limitations with ID fan capacity as a result of a dirty" air heater. However, as discussed later, the NO_x emissions would not have been any higher at the full 100% MCR condition based on the NO_x data collected as a function of boiler load. CO emissions remained low (< 75 ppm) during the testing while % loss on ignition (LOI) remained essentially unchanged. This finding was particularly significant since, as shown in **Table 1**, coal fineness was below standard grind and the coal distribution to the burners was only $\pm$ 25% of the average coal flow.

Economizer and air heater exit gas temperature as well as boiler efficiency were all unaffected by the new low NO_x system. The fuel burned during the testing was an eastern bituminous coal from Tennessee. **Table 2** summarizes the fuel analysis for this coal.

Figure 4 shows the effect of air staging on NO_x emissions. The OFA flow is expressed as % of total combustion air as measured by the hot wire anemometers in the OFA duct sections on both sides of the unit. The curve shows a steady decrease in NO_x with increasing amounts of OFA as expected. The NO_x level measured with OFA closed was 0.65 lb/10^6 Btu. Based on results of previously testing the CCV burner in our combustion test furnace, lower NO_x values could have been produced with OFA closed if operations would have allowed us to replace the coal spreaders with lower swirl coal spreaders. Power demand requirements during this past summer precluded our efforts to test this condition. However, NO_x emissions were predicted to be < 0.5 lb/10^6 Btu with burners only.

Figure 5 shows how the NO_x emissions remained relatively constant with a decrease in boiler load by steadily decreasing the amount of OFA flow. If the OFA remained wide open, NO_x emissions would have decreased significantly. TPC Linkou Unit 1 did not experience any furnace waterwall flame impingement before or after the low NO_x burner retrofit. The slagging and fouling characteristics did not change.

A tremendous benefit observed with the burner air shrouds during the testing was the ability to bias the burner air flow from side to side on the unit. The testing was performed during a period when one (1) air heater was considerably more dirty than the other and normal soot blowing practice would not effectively clean it. The air heater pressure drop on the dirty side was twice the pressure drop on the other resulting in a significant O_2 and CO emission imbalance side to side, as measured at the economizer outlet. The burner shrouds were consequently adjusted to equalize this O_2 imbalance. Final shroud positions established on a burner column basis were 35%, 24%, 16%, 16%, 18% and 30% open. By biasing the shrouds such as this, the O_2 measured at the economizer outlet became balanced, CO emissions were reduced and superheater tube metal temperatures were more uniform across the unit.

PROJECT COSTS

The delivered and supervised cost for the complete low NO_x combustion system retrofit for Taiwan Power Company Linkou Unit 1 was $10.8/kw. This included the low NO_x burners, advanced OFA system, boundary air system, burner and OFA controls, aerodynamic flow model study, start-up service, pre-retrofit baseline and post-retrofit performance and acceptance testing. The estimated cost for the Taiwan project <u>without</u> this OFA system would have been $8.5/kw.

The OFA system alone comprised over 20% of the total cost due to the non-conventional arrangement selected. Ports were installed along both sidewalls and along the front wall with a complex U-shaped header or feed duct design. This was implemented to ensure proper mixing is maintained in a relatively short furnace residence time from the OFA port elevation to the furnace exit.

More conventional and less costly OFA system designs by Riley would normally include OFA ports on the firing wall only with individual ducts connected from the top of the windbox to each OFA port. A complete header system is not always required.

PILOT TESTING EXPERIENCE

A prototype CCV™ burner was installed and tested last spring in the Riley Coal Burner Test Facility (CBTF). The Riley CBTF, located in Worcester, Massachusetts and shown in **Figure 6** is a horizontal tunnel furnace with the burner mounted on one end and the exhaust exiting the other end. The furnace has a nominal firing capacity of 100 million Btu/hr on coal. The firing chamber is approximately 18' wide and 60' long. The straight vertical side walls extend 18' above the furnace hopper. The test furnace is designed to simulate flame zone temperatures in actual utility boilers. Insulating refractory covers the interior walls of the furnace up to 40' from the firing wall. A water jacket, which surrounds the steel vessel, provides cooling.

Furnace ports located on the sidewalls are used to simulate overfire air at various furnace residence times. Gaseous emissions are continuously measured at the furnace exit.

The primary purpose of the testing was to develop design enhancements for the CCV™ burner to achieve greater NO_x reduction without the need for OFA. The other purpose was to evaluate the effect of various fuel characteristics on emissions performance. A total of four (4) different eastern bituminous coals were evaluated during the test program. As shown in **Table 3**, the volatile content ranged from 18.9% for Coal D to 35.7% for Coal B. The resulting fuel factor or fixed carbon/volatile matter ratio ranged from 1.42 to 3.51. Combined with this data was data collected in 1988 from testing the CCV™ burner on two (2) additional coals having FC/VM ratios of 1.17 and 1.87 (3).

The prototype burner was designed with a special coal spreader where the blade angle could be adjusted on line for test purposes. For commercial operation, this coal spreader would remain as a "fixed" design. The design enhancement added to the prototype burner was the inclusion of a secondary air diverter mounted adjacent to the discharge end of the coal nozzle. **Figure 7** shows a drawing of the prototype burner design with the new secondary air diverter.

The secondary air diverter causes more secondary air to initially flow away from the primary combustion zone, thus expanding the reducing zone at the burner discharge. This promotes greater devolatilization of the coal in this reducing environment which contributes to greater NO_x reduction. Recirculation eddies created on the backside of the diverter also helps to intensify ignition of the coal and helps to promote the devolatilization process. Based on laboratory testing, the diverter maintains a well attached flame with good ignition close to the coal nozzle tip for a wide variation in coal spreader designs. This flexibility allows for better NO_x control over a wide range of operating conditions and coal properties.

Figure 8 shows the effect of adjusting the coal spreader angle on NO_x emissions comparing the original CCV™ burner design (CCV™ 88) with the prototype design, having the new secondary air diverter (CCV™ 92). The data, collected during unstaged operation (OFA ports closed), shows a significant improvement in NO_x performance for the CCV™ 92 at spreader angles from 30° maximum down to 15°. Below 15°, both burner designs behaved similarly. A data point representing the level of NO_x measured in the CBTF from Riley's pre-NSPS high turbulence flare type burner is also shown for comparison. The testing showed the capability of the CCV™ burner design (Model 92) to reduce NO_x emissions > 60% <u>without</u> the requirement for OFA ports.

Figure 9 shows the effect of air staging, on NO_x emissions. Similar to the previous figure, the data compares CCV™ 88 and CCV™ 92 low NO_x burner designs with the original flare type burner. The CCV™ 92 burner design was capable of producing NO_x emissions below 0.27 lb/10^6 Btu when staged to 0.9 burner zone stoichiometry. An important discovery though was that the NO_x performance measured from the CCV™ 92 burner design was less sensitive to the degree of staging than the previous burner designs.

Figure 10 shows the effect of variations in fuel factor or FC/VM ratio on NO_x and CO emissions performance. The data was collected while testing the CCV™ 92 burner design with adjustable coal spreader blades set at 15° with respect to the burner axis. Contrary to what we anticipated, the NO_x performance was insensitive to this fuel property variation. Previous investigators had found that NO_x emissions increase with an increase in FC/VM ratio (4). If anything, the data collected on the CCV™ 92, showed a decrease in NO_x with an increase in FC/VM ratio during staged operation. For unstaged operation, the NO_x curve was relatively flat.

A more significant effect of the fuel factor was the impact on CO emissions. This was consistent with what was expected. CO emissions increased 50% with an increase in FC/VM ratio from 1.4 to 2.0. CO emissions then increased at only a moderate rate up to FC/VM = 3.51. Fly ash LOI increased similarly. The CO emissions were slightly higher for staged operation.

SUMMARY

Riley Stoker has successfully retrofitted low NO_x combustion system technology to Taiwan Power Company Linkou Unit 1. Of particular importance was the ability of this new combustion system to achieve NO_x emissions < 0.4 lb/10^6 Btu without degradation in boiler performance despite coal fineness was below standard grind, coal pipe distribution exceeded ± 25% and one (1) air heater was considerably fouled. Independent control of the low NO_x burners, OFA system and boundary air system and the flexibility of controlling these systems contributed significantly to optimizing performance of this boiler. The burner shrouds and OFA dampers were all easily controlled from the control room. Boundary air was controlled manually. The air flow model study performed was instrumental during the design phase of this project. Location and design of the partition plate in the hot air ducts and determining the proper location for flow measurement were the most significant benefits from this study.

The delivered and supervised cost for this project was approximately $3.2 million which equates to $10.8/kw. A significant portion of this cost was associated with the non-conventional OFA system design. The non-conventional arrangement was necessary because of the relatively short furnace residence time for carbon burnout above the OFA port elevation. Conventional OFA system designs are less complex and less costly to implement.

The latest CCV™ burner design enhancement incorporating the secondary air diverter has improved NO_x reduction performance 25-30%. NO_x emission levels below 0.35 lb/10^6 Btu were measured in the Riley Coal Burner Test Facility <u>unstaged</u> or without the use of overfire air. NO_x levels well below 0.30 lb/10^6 Btu were recorded when combining the CCV™ burner with overfire air. This performance was also maintained over a wide range of coal properties.

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Table 1
Taiwan Power Company Linkou Unit 1
Emissions Test Results

Test Type	Baseline	Baseline	Post Retrofit	Post Retrofit
Date	2/88	7/91	8/92	8/92
Burner Design	Flare	Flare	CCV	CCV
OFA, %	0	0	24	26
NO_x, lb/10^6 Btu	1.04	0.90	0.43	0.38
CO, PPM	20	300	50	70
Flyash LOI, %	-	8.5	8.2	-
Bottom Ash LOI, %	-	-	3.3	-
Econ. Gas Out. Temp.°F	-	650	635	-
AH Gas Out Temp. °F	-	291	297	-
Boiler Efficiency, %	-	88.12	89.25	-
Coal Fineness % - 50 Mesh % - 200 Mesh	 96.9 67.8	 94.0 64.3	 95.5 66.1	 95.5 66.1

Table 2
Taiwan Power Company
Linkou Unit 1 Fuel Analysis

H_2O (%)	5.00
VM (%)	35.10
FC (%)	49.40
Ash (%)	10.50
C (% dry)	73.40
H (% dry)	5.00
O (% dry)	8.14
N (% dry)	1.46
S (% dry)	0.90
HHV (Btu/lb)	12,418

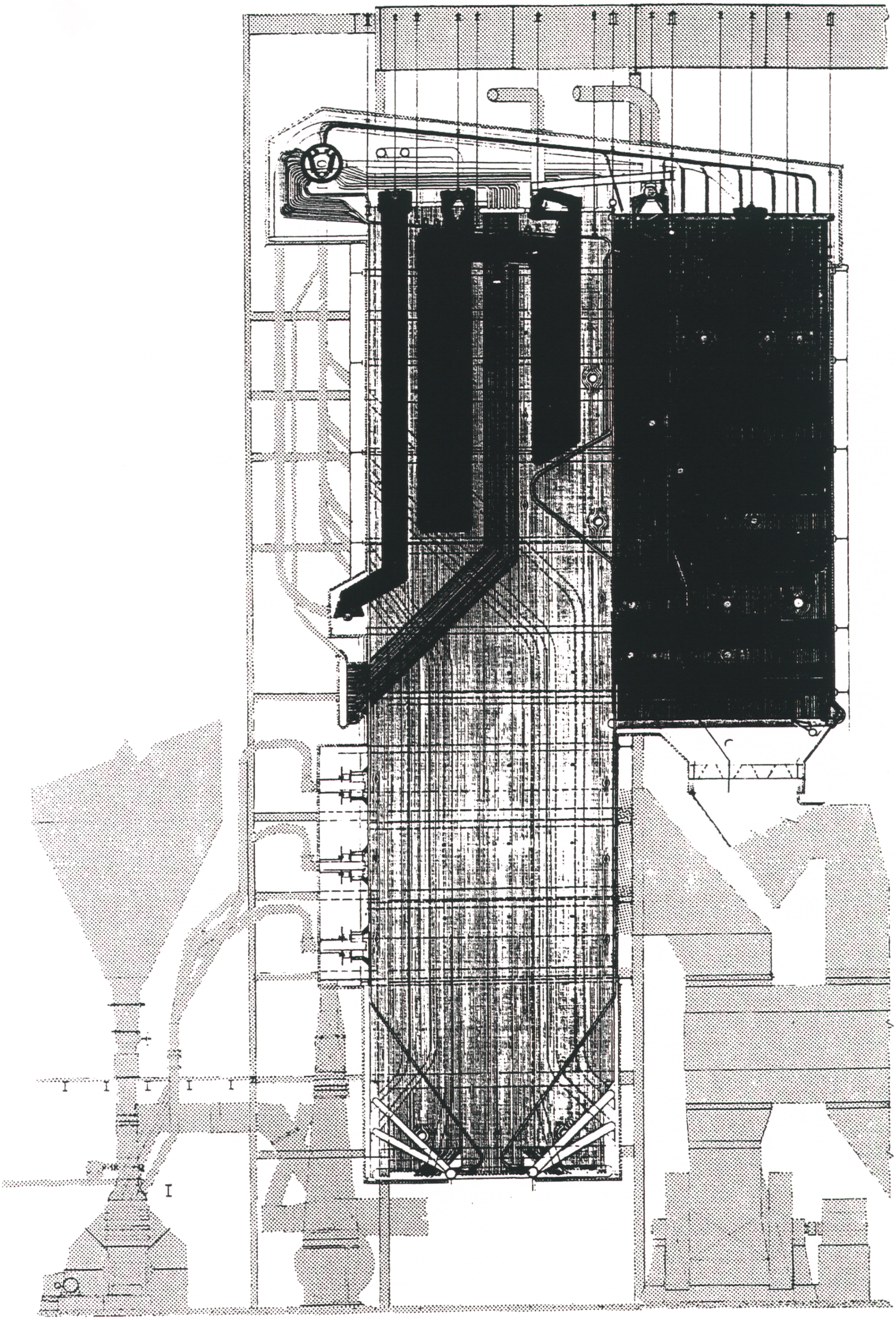

Figure 1. Taiwan Power Company Linkou Unit 1 Original Boiler Configuration

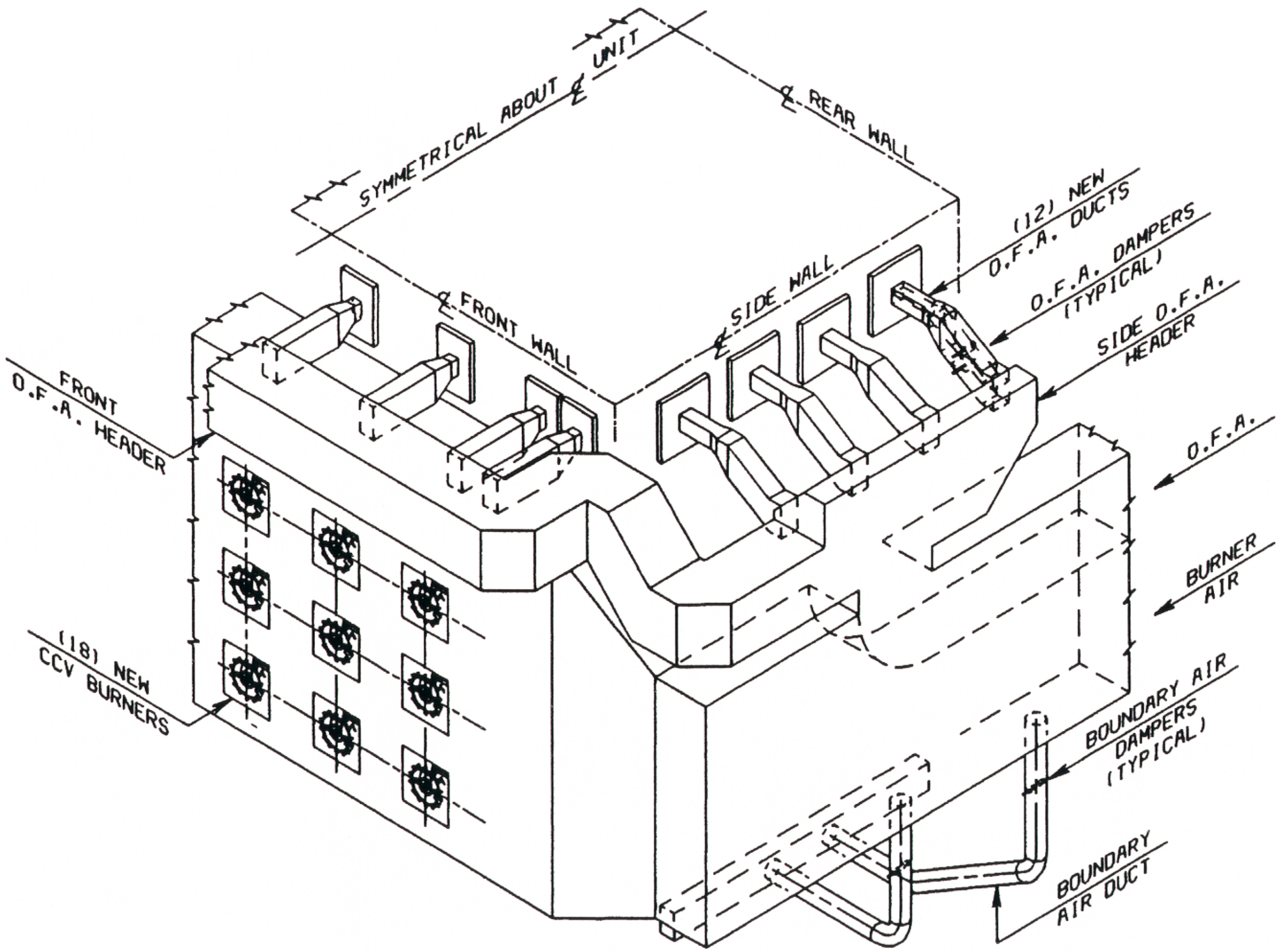

Figure 2. Low NO_x Combustion System Retrofit for Taiwan Power Company Linkou Unit 1 300 MW Boiler

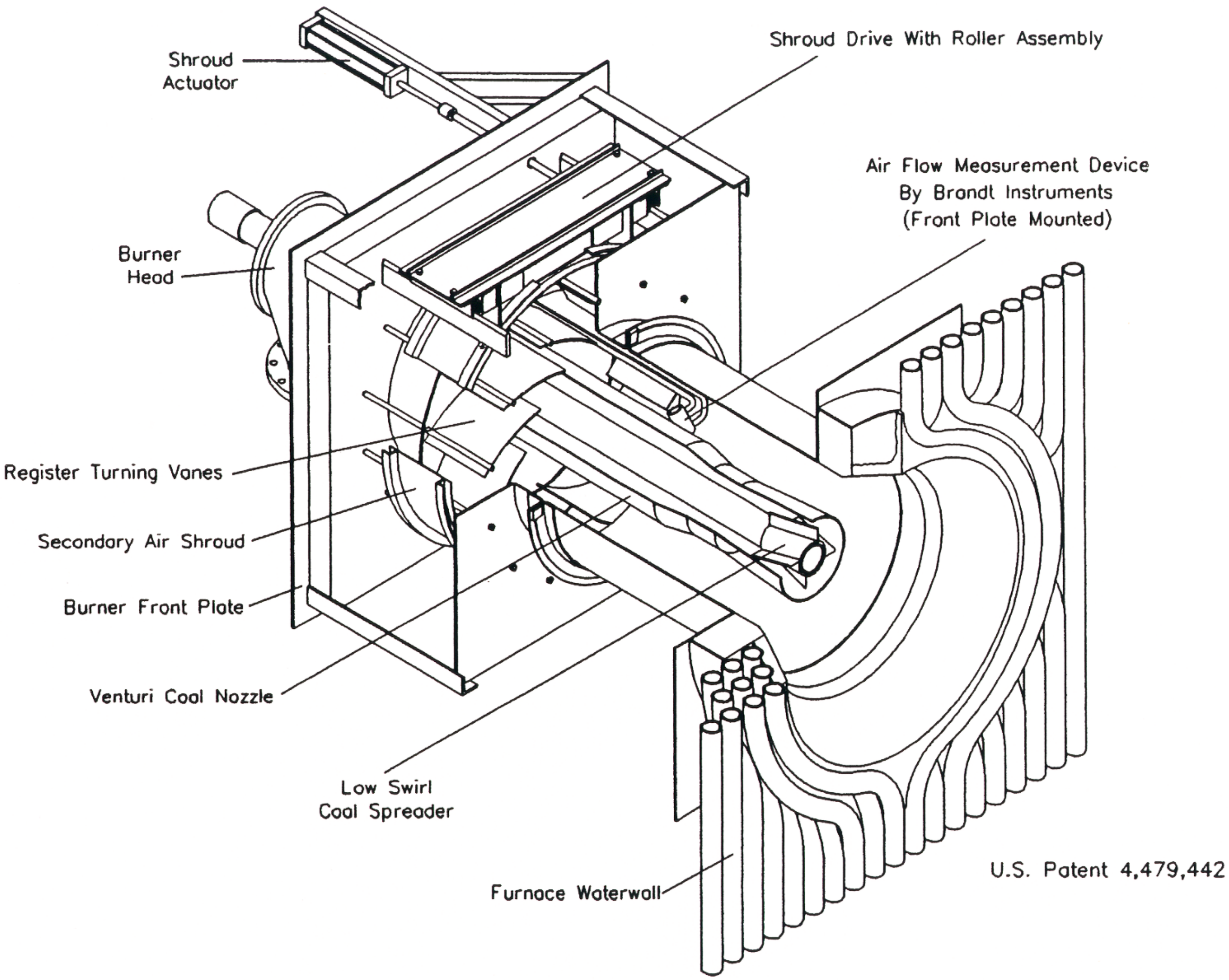

Figure 3. **Riley Low NO_x Controlled Combustion Venturi (CCV™) Burner**

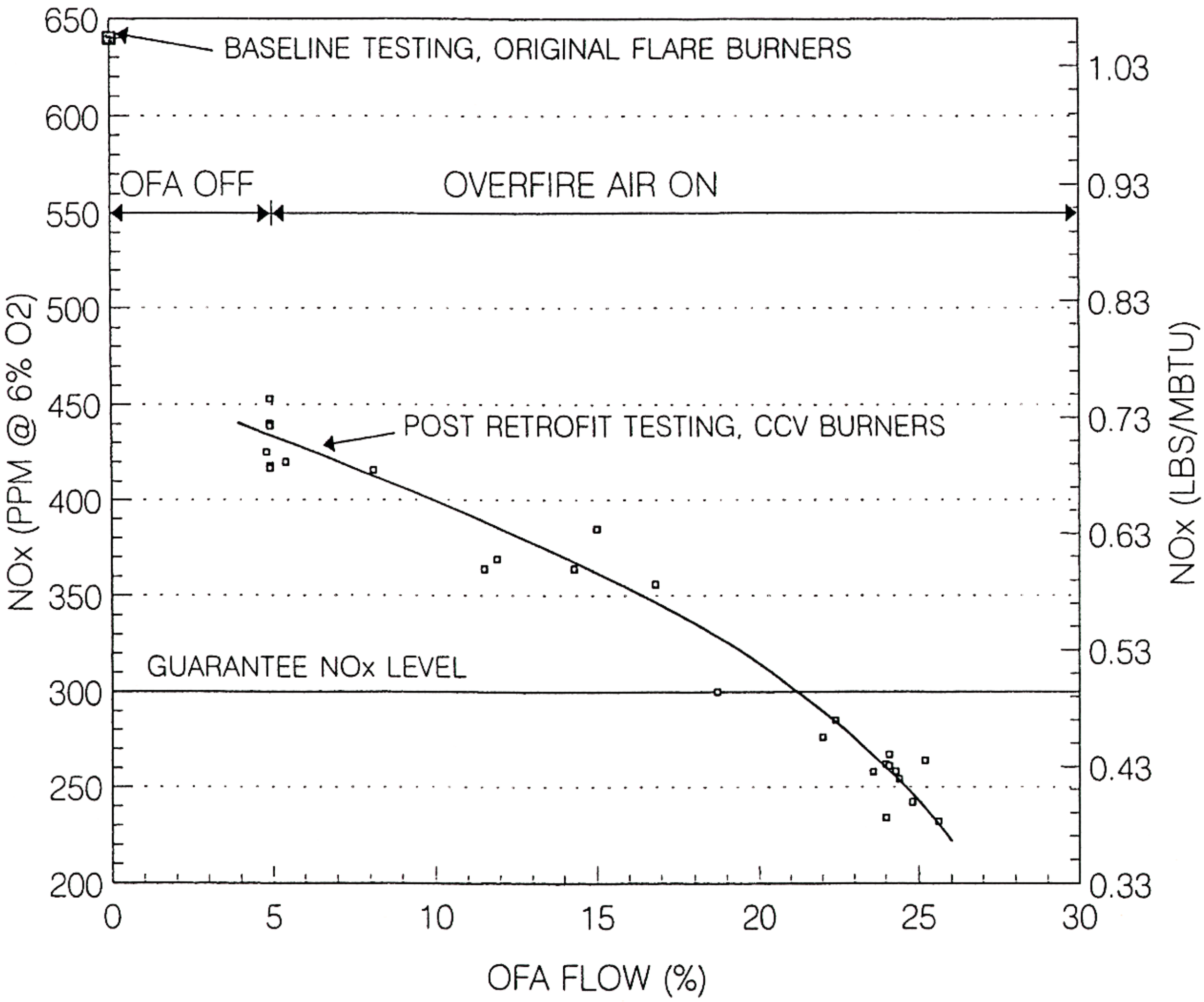

Figure 4. **NO_x Emission Test Results at Full Load 300 MW Utility Boiler**

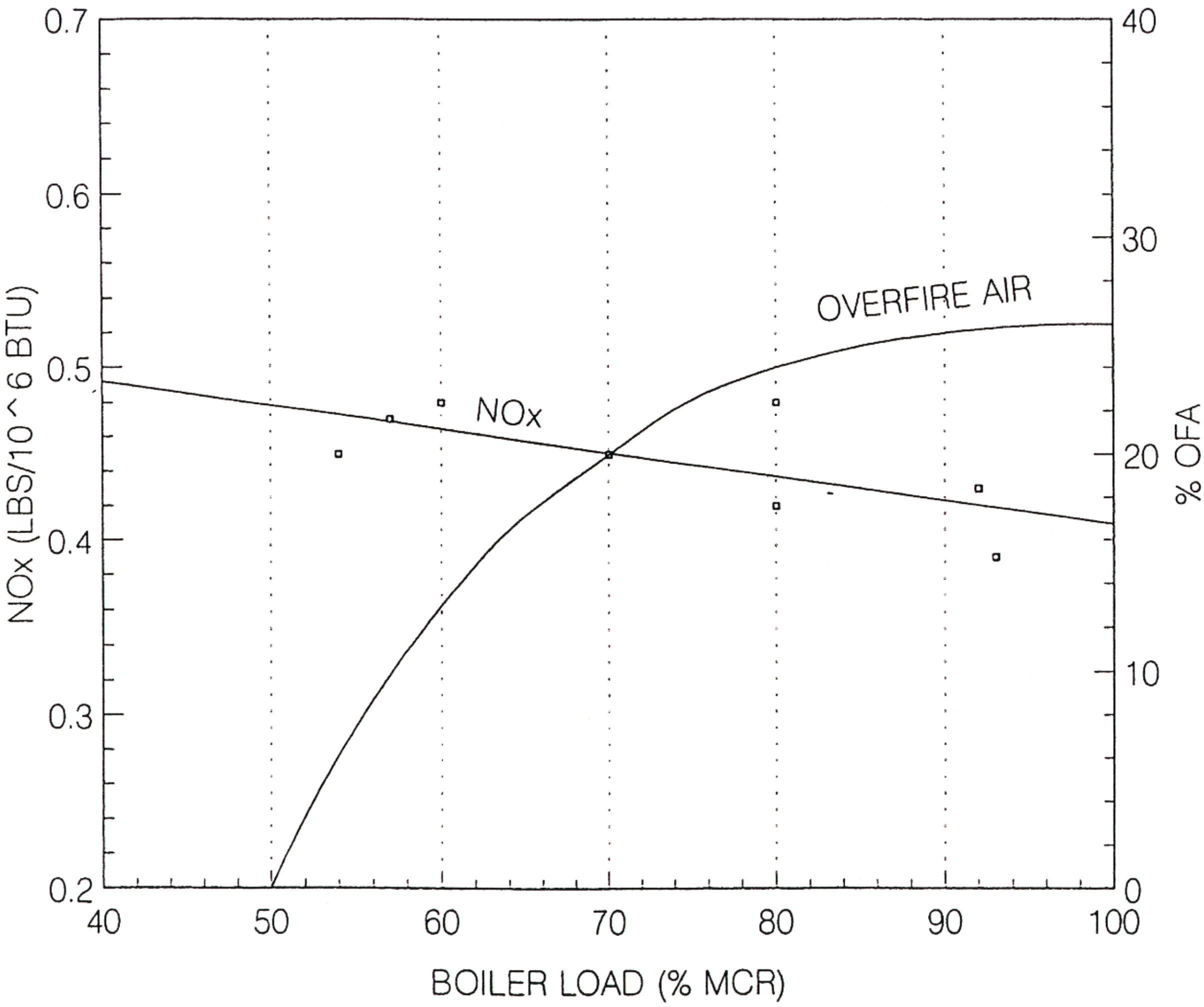

Figure 5. NO_x vs. Load - 300 MW Utility Boiler

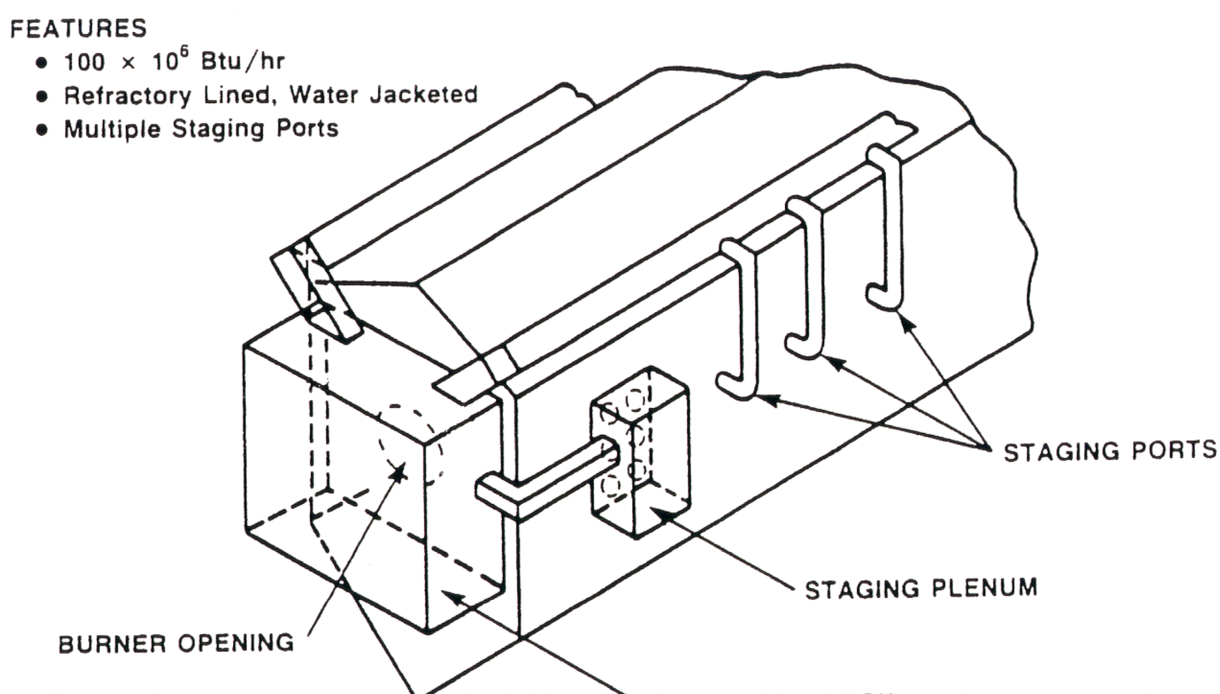

Figure 6. Riley Coal Burner Test Facility (CBTF)

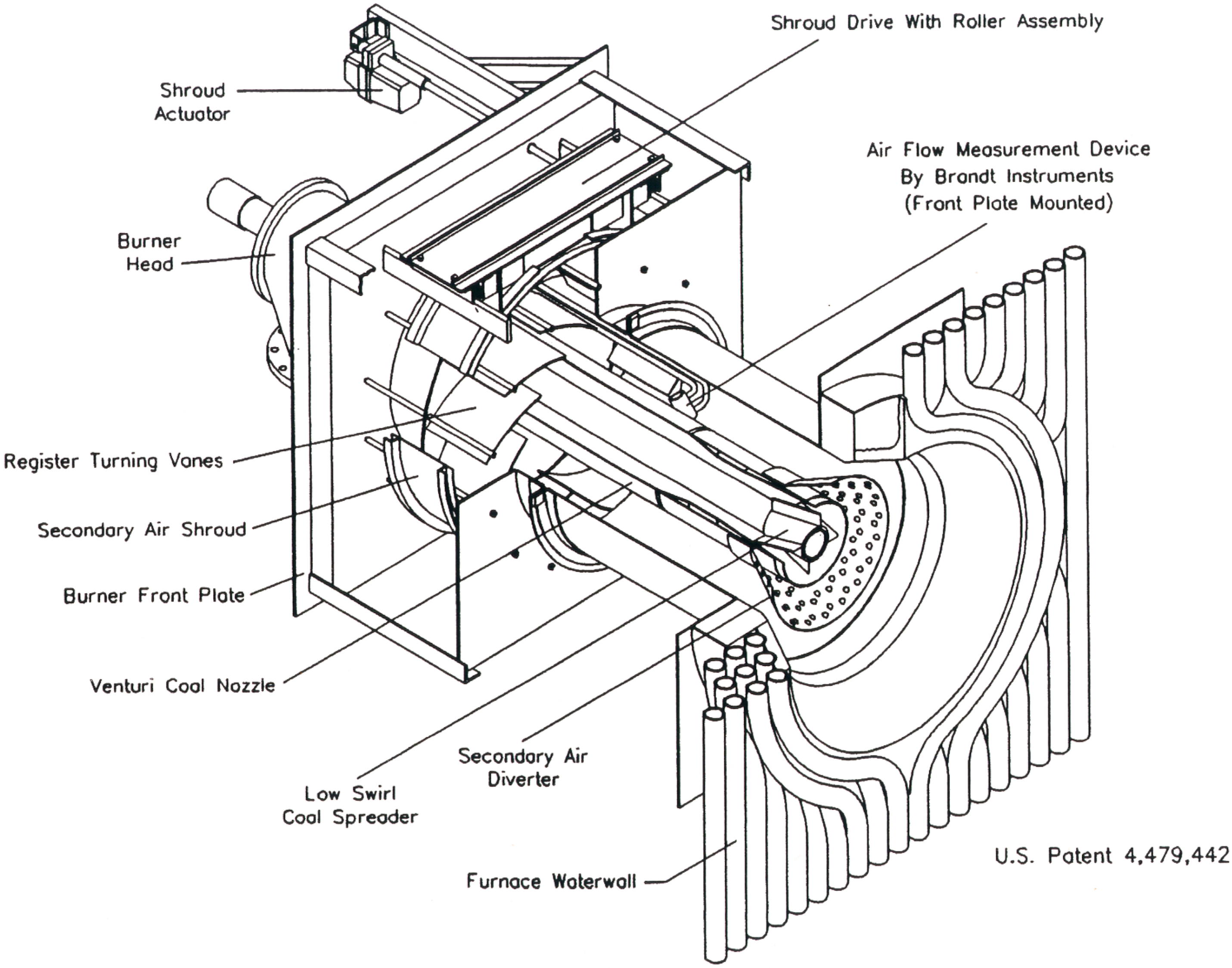

Figure 7. Riley Low NO_x CCV™ Burner with Secondary Air Diverter

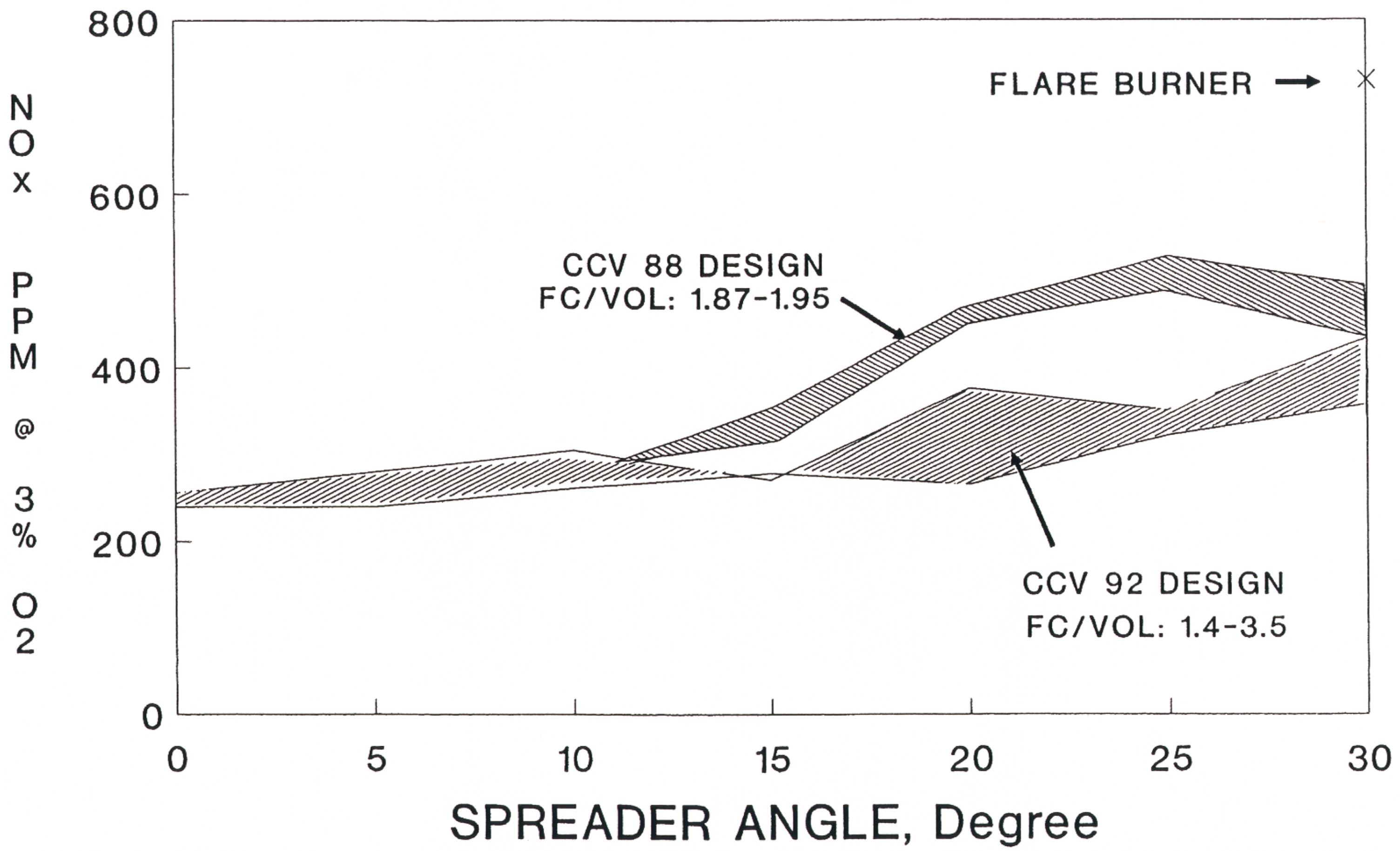

Figure 8. The Effect of Coal Spreader Angle on NO_x Emissions
CBTF Pilot Test Results

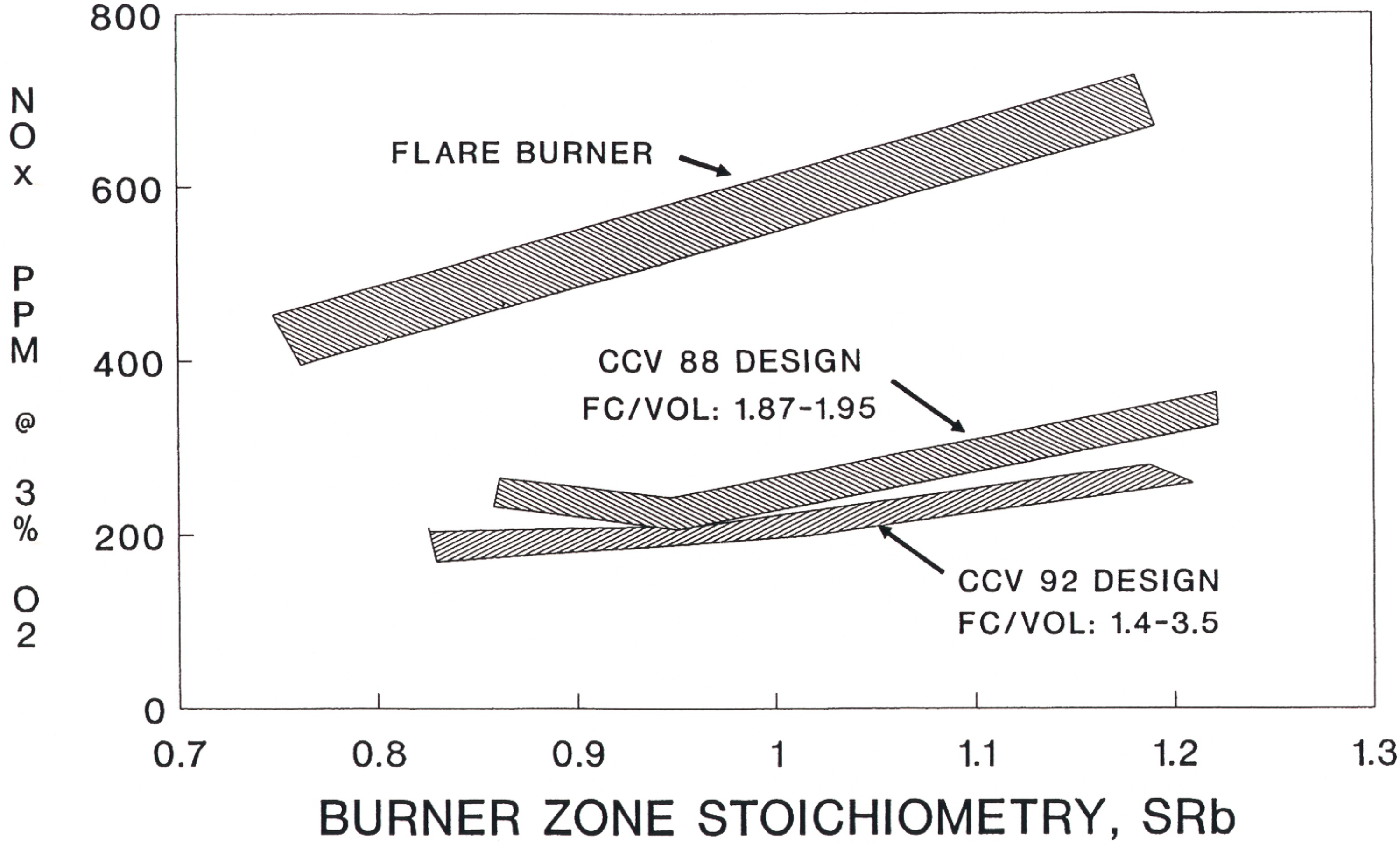

Figure 9. **The Effect of Air Staging on NO_x Emissions CBTF Pilot Test Results**

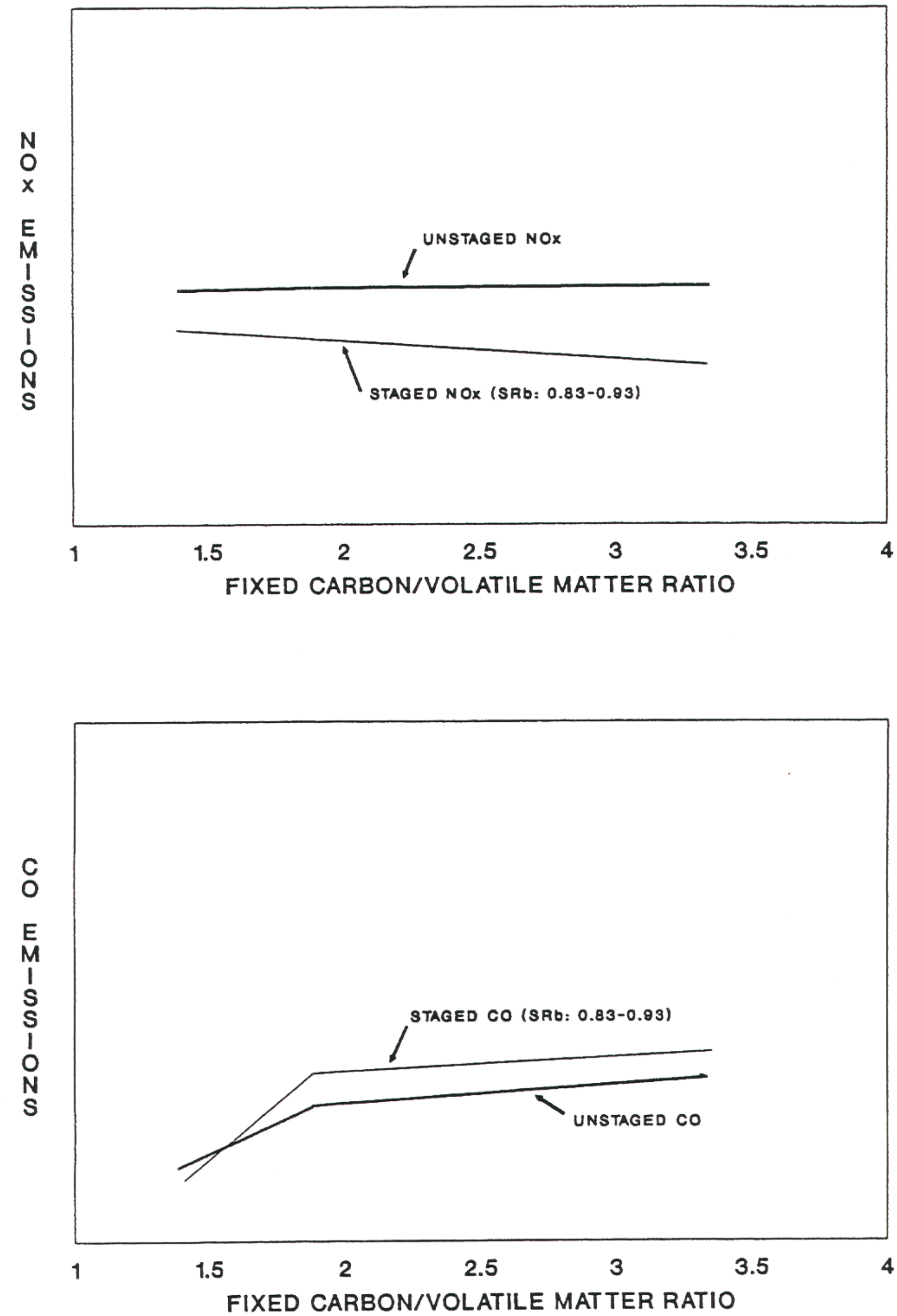

Figure 10. The Effect of Fuel Factor (FC/VM Ratio) on NO_x and CO Emissions, CBTF Pilot Test Results